SIBOGA-EXPEDITIE

Siboga-Expeditie

UITKOMSTEN

OP

ZOOLOGISCH, BOTANISCH, OCEANOGRAPHISCH EN GEOLOGISCH GEBIED

VERZAMELD IN

NEDERLANDSCH OOST-INDIË 1899—1900

AANBOORD **H. M. SIBOGA** ONDER COMMANDO VAN

Luitenant ter zee 1^{e} kl. G. F. TYDEMAN

UITGEGEVEN DOOR

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Onderzoek van Oost- en West-Indië)

LEIDEN
E. J. BRILL
1951

Siboga Expeditie
IVa

THE FORAMINIFERA OF THE SIBOGA EXPEDITION

BY

J. HOFKER

PART III

ORDO DENTATA, SUB-ORDINES PROTOFORAMINATA, BIFORAMINATA, DEUTEROFORAMINATA

FAMILIES VALVULINIDAE, BOLIVINIDAE, BULIMINELLIDAE, BULIMINIDAE. UVIGERINIDAE, VIRGULINIDAE, CASSIDULINIDAE, CERATOBULIMINIDAE, EPONIDAE, CIBICIDAE, EPISTOMINIDAE, ROBERTINIDAE, ALABAMINIDAE, LATICARINIDAE, CONORBIDAE, AMPHISTEGINIDAE, PULVINULINIDAE, CYMBALOPORETTIDAE, VALVULINERIDAE, ROTALIDAE

With 348 textfigures

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1951

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PRINTED IN THE NETHERLANDS

INDEX TO PART III

- Introduction . . . 1
  - Trimorphism or Dimorphism? . . . 2
  - The foramina . . . 5
  - The septal foramen . . . 6
  - The pores . . . 9
  - The material . . . 12
  - Methods . . . 12

- Ordo Dentata . . . 14
- Short characteristics of the families . . . 17
  - *Valvulinidae* . . . 17
  - *Bolivinidae.* . . . 17
  - *Conorbinidae* . . . 17
  - *Valvulineridae* . . . 18
  - *Tinoporidae* . . . 18
  - *Marginolamellidae* . . . 18
  - *Ceratobuliminidae* . . . 18
  - *Camerinidae* . . . 18
  - *Buliminellidae* . . . 18
  - *Buliminidae* . . . 18
  - *Uvigerinidae* . . . 19
  - *Virgulinidae* . . . 19
  - *Cassidulinidae* . . . 19
- Family *Valvulinidae* . . . 19
- Genus **Karreriella** . . . 21
  - *Karreriella bradyi* Cushman . . . 21
- Genus **Listerella** . . . 25
  - *Listerella primaeva* (Cushman) . . . 25
  - *Listerella minuta* nov. spec. . . . 27
  - *Listerella milleti* Cushman . . . 27
- Genus **Valvotextularia** nov. genus. . . . 30
  - *Valvotextularia milleti* (Cushman) . . . 30
  - *Valvotextularia stricta* (Cushman) . . . 33
- Genus **Valvopavonina** nov. genus . . . 35
  - *Valvopovonina flabelliformis* (d'Orbigny) . 35
- Genus **Valvobifarina** nov. genus . . . 39
  - *Valvobifarina mackinnoni* (Millet) . . . 40

- Sub-Ordo Protoforaminata. . . . 42
- Family *Bolivinidae* . . . 43
- Genus **Bolivina** . . . 44
  - *Bolivina rhumbleri* Franke . . . 50
  - *Bolivina seminuda* Cushman. . . . 51
  - *Bolivina ramosa* nov. spec. . . . 52
  - *Bolivina vadescens* Cushman. . . . 52
  - *Loxostoma incertum* nov. spec. . . . 55
  - *Bolivina spinescens* Cushman. . . . 57
  - *Loxostoma strigosum* (Brady) . . . 59
  - *Rectobolivina bifrons* (Brady) . . . 60
  - *Sagrina tessellata* Brady. . . . 63
  - *Rectobolivina columellaris* (Brady) . . . 68
  - *Loxostoma karrerianum* (Brady). . . . 72
  - *Bolivina tortuosa* Brady. . . . 75
  - *Bolivina robusta* Brady . . . 76
  - *Bolivina compacta* Sidebottom . . . 80
  - *Bolivina albatrossi* Cushman. . . . 84
  - *Loxostoma cuneatum* nov. spec. . . . 87
- The genus **Bifarina,** exit . . . 90
  - *Rectobolivina fimbriata* (Millet) . . . 91
  - *Rectobolivina virgula* (Brady) . . . 93
  - *Bolivina pygmaea* Brady . . . 94
  - *Bolivina alata* (Seguenza) . . . 96
  - *Bolivina hantkeniana* Brady . . . 98
  - *Bolivina quadrilatera* (Schwager). . . . 102
- The genus **Bolivinita** Cushman, exit . . . 107
  - *"Bolivinita" eleyi* (Cushman) . . . 109
  - *Loxostoma amygdalaeforme* (Brady). . . 111
  - *Rectobolivina* nov. spec.. . . . 114
  - *Rectobolivina dimorpha* (Parker et Jones) . 116
- Family *Buliminellidae.* . . . 121
- On some fossil species of *Buliminella* . . . 123
  - *Buliminella madagascariensis* (d'Orbigny) var. *spicata* Cushman et Parker. . . . 127
  - *Buliminella elegantissima* (d'Orbigny) . . 131
  - *Buliminoides williamsoni* (Brady) . . . 133
  - *Buliminella subtenuis* (Cushman) . . . 133
- Genus **Allomorphina** . . . 138
  - *Allomorphina pacifica* nov. spec.. . . . 140
- Family *Buliminidae* . . . 140
- Genus **Praebulimina** . . . 144
- Genus **Bulimina** . . . 146
  - *Bulimina versa* Cushman et Parker . . . 146
  - *Bulimina trigonalis* Ten Dam . . . 147
  - *Bulimina aculeata* d'Orbigny. . . . 151
  - *Bulimina marginata* d'Orbigny . . . 154
  - *Bulimina rostrata* Brady. . . . 157

Bulimina pagoda Cushman et Parker . . . 160
Bulimina clava Cushman et Parker . . . 163
Reussella aequa Cushman et MacCulloch . . 168
Reussella weberi nov. spec. 170
Chrysalidina dimorpha (Brady) 175
Genus **Bitubulogenerina** 178
Bitubulogenerina vertebralis (Cushman) . . 178
Bitubulogenerina lobata (Brady). 180
Bitubulogenerina convallaria (Millet) . . 181
Bitobulogenerina elongata (Millet) . . . 183
Family *Uvigerinidae* 183
Genus **Praeuvigerina** nov. genus 188
Genus **Angulogerina** 189
Angulogerina oligocaenica (Andreae) . . 190
Angulogerina ornata Cushman 193
Angulogerina (Trifarina) tricarinata (d'Orbigny) 196
Angulogerina occidentalis (Cushman) . . 201
Genus **Aluvigerina** nov. genus. 201
Aluvigerina pygmaea (d'Orbigny) . . . 203
Aluvigerina indonesiae nov. spec.. . . . 206
Genus **Neouvigerina** nov. genus 206
Neouvigerina ampullacea (Brady) . . . 208
Neouvigerina interrupta (Brady) 213
Neouvigerina porrecta (Brady) 213
Genus **Euuvigerina** nov. genus. 217
Euuvigerina tenuistriata (Reuss). . . . 218
Euuvigerina peregrina (Cushman) . . . 219
Euuvigerina aculeata (d'Orbigny) . . . 226
Genus **Siphogenerina** 232
Siphogenerina raphana (Parker et Jones) . . 233
Family *Virgulinidae* 236
Genus **Virgulina** 237
Virgulina subdepressa Brady. 238
Virgulina schreibersiana Czjzek 241
Virgulina complanata Egger. 244
Virgulina concava Höglund 246
Virgulina pauciloculata Brady 247
Genus **Praeglobobulimina** nov. genus . . . 248
Praeglobobulimina spinescens (Brady) . . 249
Genus **Protoglobobulimina** nov. genus. . . 252
Protoglobobulimina pupoides (d'Orbigny) . 252
Protoglobobulimina turgida (Bailey). . . 254
Genus **Globobulimina** 256
Globobulimina elongata (Cushman) . . . 257
Globobulimina pacifica Cushman. . . . 260
Family *Cassidulinidae* 262
Genus **Cassidella** nov. genus 264
Cassidella tegulata (Reuss) 265
Cassidella oligocenica nov. spec. 265
Cassidella squamosa (d'Orbigny). . . . 268
Cassidella complanata (Egger) 271
Cassidella pacifica nov. spec. 273
Genus **Pleurostomella** 274
Pleurostomella alternans Schwager . . . 274
Genus **Ehrenbergina** 278
Ehrenbergina hystrix Brady 279
Ehrenbergina pacifica Cushman 281
Genus **Cassidulina** d'Orbigny 289
Cassidulina subglobosa Brady 289
Cassidulina laevigata d'Orbigny 294
Cassidulina tortuosa Cushman 298
Genus **Cassidulinoides** 301
Cassidulinoides subsquamosa (Egger). . . 302

SUB-ORDO BIFORAMINATA 306
The toothplate of the *Biforaminata* 308
Family *Ceratobuliminidae* 313
Genus **Lamarckina** 313
Lamarckina scabra (Brady) 313
Genus **Ceratobulimina** 316
Ceratobulimina pacifica Cushman et Harris . 316
Family *Eponidae* 321
Genus **Pulvinulinella**. 321
Pulvinulinella exigua (Brady) 322
Genus **Eponides** 326
Eponides calida Cushman et Cole . . . 327
Eponides repanda (Fichtel et Moll) . . . 330
Family *Cibicidae* 332
Genus **Parrella** 333
Parrella venusta (Brady). 333
Parrella culter (Parker et Jones) 336
Genus **Cibicides** 341
Cibicides refulgens Montfort. 346
Cibicides akneriana (d'Orbigny). . . . 348
Cibicides wuellerstorfi (Schwager) . . . 350
Cibicides margaritifera (Brady) 352
Cibicides mundula (Brady, Parker et Jones) . 354
Cibicides ungeriana (d'Orbigny) . . . 357
Cibicides hyalina nov. spec. 359
Cibicides aequipunctata nov. spec. . . . 362
Cibicides (Anomalina) ammonoides (Reuss) . 364
Cibicides (Anomalina) flinti (Cushman) . . 367
Genus **Siphonina** 369
Siphonina reticulata (Brady). 369
Family *Epistominidae* 371
Genus **Epistomina** 371
Epistomina stelligera Uhlig 372
Epistomina elegans (d'Orbigny) 375
Family *Robertinidae* 379
Genus **Robertinoides** 379
Robertinoides oceanica (Cushman et Parker) . 380
Genus **Pseudobulimina** 386
Pseudobulimina convoluta (Williamson). . 386

Family *Alabaminidae* 389
Genus **Alabamina** 390
  Alabamina solnäsensis Brotzen 390
  Alabamina tubulifera (Heron-Allen et Earland) 392
  Alabamina procera (Brady) 396
Genus **Gyroidina** 399
  Gyroidina soldanii d'Orbigny. 401
  Gyroidina tenera (Brady) 403
  Gyroidina broeckhiana (Karrer) 403
Genus **Laticarinina** 408
  Laticarinina pauperata (Parker et Jones) . . 408

SUB-ORDO DEUTEROFORAMINATA 412
Genus **Conorbis** nov. genus 418
  Conorbis mitra nov. spec. 418
  Conorbis cf. *bradyi* (Cushman) 420
Genus **Discobolivina**, including the genera **Patellina, Patellinella** and **Patellinoides** . . 422
  Discobolivina conica Heron-Allen and Earland 425
  Discobolivina nitida nov. spec. 428
  Discobolivina ambulacrata (Moebius) . . 430
  Discobolivina inconspicua (Brady) . . . 431
Genus **Neoconorbina** nov. genus 433
  Neoconorbina nitida (Williamson) . . . 433
  Neoconorbina marginata nov. spec. . . . 435
  Neoconorbina neapolitana nov. spec. . . . 438
  Neoconorbina pacifica nov. spec. . . . 438
Genus **Amphistegina** 442
  Amphistegina radiata Fichtel et Moll . . 444
Family *Pulvinulinidae* 448
Genus **Discopulvinulina**, nov. genus . . . 448
  Discopulvinulina turbo (d'Orbigny) . . . 449
  Discopulvinulina pacifica nov. spec. . . . 452
  The *"Discorbis" globularis*-group . . . 452
  Discopulvinulina bradyi (Cushman) . . . 457
  Discopulvinulina globularis (d'Orbigny) . 460
  Discopulvinulina macropora nov. spec. . . 460
  The *lobatula*-group 461
  Discopulvinulina pseudolobatula nov. spec. . 462
  Discopulvinulina hyalina nov. spec. . . . 466
Genus **Conorbella** nov. genus 466
  Conorbella pulvinata (Brady) 470
  Conorbella tabernacularis (Brady) . . . 470
Genus **Asterigerinata** 472
  Asterigerinata mamilla (Williamson) . . 472
Genus **Cymbaloporetta** 477
Family *Valvulineridae* 484
Genus **Gavelinopsis** nov. genus. 485
  Gavelinopsis praegeri (Heron-Allen et Earland) 486
Family *Rotalidae* 491
Genus **Streblus** 491
  The *Streblus beccarii*-group 492
  Streblus beccarii (Linné) 500
  Streblus batavus nov. spec. 501
  Streblus turgidus nov. spec. 502
Genus **Asterorotalia** nov. genus 502
  Asterorotalia inflata (Millet) 504
  Asterorotalia pulchella (d'Orbigny) . . . 505
Genus **Hyalinea** nov. genus 508
  Hyalinea baltica (Schroeter) 508

RESULTS

This work was carried out in order to try to solve many questions in respect to systematics, bionomics and other important questions, such as geographic ones, of the Foraminifera. A summary of the results of these investigations may be useful.

Bionomics.

Le Calvez has distinguished several manners, in which reproduction of Foraminifera takes place. I could find statictically many instances for the trimorphic kind of reproduction, but in other instances dimorphism seems to be the rule. Paratrimorphism and apogamy were stated also. It was very important to observe, that trimorphic reproduction was found especially in the more primitive or geologically older species, whereas in more advanced species and even in whole genera, the reproduction-scheme was found to tend to become paratrimorphic, dimorphic or even apogamic. This result is of high importance, as well in respect to bionomics, as to systematic questions.

Foramina.

In the foramina I have distinguished between protoforamina and deuteroforamina. This difference was found to be of great influence in systematic matters. It could be carried on by laying stress on the toothplate and its development and place. This toothplate is a characteristic which is found in most of the more primitive forms of the large group of Foraminifera, here gathered in a special ordo, the *Dentata.*

Pores.

A very valuable character proved to be the place and the structure of the pores. Proto- and deuteropores have been distinguished in this paper, and it was stated that more primitive and geologically older species within a group always show protopores, whereas deuteropores develop in more advanced species in a group. So, this character must be of high systematic importance.

Methods.

Several new methods have been used. Each species was studied in its outer and inner structural characters, always sections were made. In several cases, in which inner structures, especially of the toothplate, were difficult to observe, the method of using series of glassplates, on which successive sections were drawn, was used with good result. It was proved, that in nearly all cases, in which fossil material, even Jurassic, was studied, all these methods could be used too; the observation of the material in a clarifier, on which method was laid stress by Höglund and myself, showed to be indispensable.

Valvulinidae.

In the **Valvulinidae** protopores were found in all cases observed; this discovery made it clear, that there is not such a large gap between *Agglutinantia* and *Calcarea,* as was hitherto believed.

ew Sub-Ordines.

Many new names have been introduced. The new ordo of the **Dentata** has already been entioned. New Sub-Ordines are: **Protoforaminata, Deuteroforaminata** and **Biforaminata**. These mes resulted from the study of the different structure of the apertural conditions.

ew Families.

The following new Families have been established: **Buliminellidae, Bolivinidae, Eponidae, bicidae, Robertinidae, Alabaminidae, Conorbidae, Pulvinulinidae,** many of them showed be necessary in respect to our knowledge of fossil forms.

ew Genera.

Many new generic names have been founded. Several species, hitherto known as *Textularia,* t possessing protopores in the walls and showing characters which are found too in the **Valvu- nidae** , have been gathered in that family under the new name *Valvotextularia.* As *Pavonina* oved to be a valvuline genus, it has been renamed *Valvopavonina.* The genus *Bifarina* showed to nclose so many quite different forms, that a new genus, *Valvobifarina* had to be created. Other ew genera are: *Praebulimina, Praeuvigerina, Praeglobobulimina, Protoglobobulimina, Cassidella, iscobolivina, Neoconorbina, Discopulvinulina, Conorbella, Gavelinopsis, Asterorotalia* and *Hya- nea.* It was not always possible to uphold the rules of nomenclature, as so many described genera nd species of Foraminifera are very insufficiently known, and thus in several cases new names had be created to avoid further entanglement.

ew species.

I have maintained, as far as just possible, the specific names of many, though very badly escribed, species. It was, however, not always possible to know, whether a species, now known in its nner structure, was identical with a species, unsatisfactorily described by a former author. The same ifficulty was encountered by Höglund, who in 1947, also described many species much more etailed, than it was done by a former author, and likewise struggled with his names. In very uncertain ases a new name had to be proposed. So the following new species have been named. I have to add ere, that it proved to be necessary to divide a former species in several other species. In all these ases I based, when possible, the new species on more detailed statistic study. The new species are:

Listerella minuta, Loxostoma incertum, Loxostoma cuneatum, Allomorphina pacifica, Aluvi- erina indonesiae, Cassidella oligocenica, Cassidella pacifica, Cibicides hyalina, Cibicides equipunc- ata, Conorbis mitra, Discobolivina nitida, Neoconorbina marginata, Neoconorbina neapolitana, Neoconorbina pacifica, Discopulvinulina macropora, Discopulvinulina pacifica, Discopulvinulina seudolobatula, Discopulvinulina hyalina, Streblus batavus, Streblus turgidus.

ystematic difficulties and puzzles.

I showed, moreover, that the genera *Loxostoma* and *Rectobolivina* are no real genera, as they ave developed in many different groups of the genus *Bolivina;* though I have maintained these eneric names, I dealt with the species as belonging to a single genus, *Bolivina.* These genera *oxostoma* and *Rectobolivina* show nothing but special features of toothplates and apertures in the enus *Bolivina.* They are descriptive genera, but not genetic genera. I have already mentioned, that he genus *Bifarina* does not exist in reality. The same was proved about the so-called genus *Bolivi- ita,* as the type of this genus proved to be a true *Bolivina,* whereas the cretaceous species of it are elonging to *Siphogaudryina,* or allied to it. Moreover I showed, that these cretaceous species have lready been named by Ehrenberg, as *Loxostomum.* I made it clear, that the genus *Allomorphina* is not related to *Chilostomella,* but to *Buliminella.* In the same way the genus *Candeina* is related to *Vigulinella.* Moreover, I suggested in another paper, that *Virgulinella* belongs to the *Cassidulinidae.* Many *species,* hitherto gathered in the genus *Virgulina,* were shown to belong to the *Cassidulinidae,* and consequently the genus *Virgulina* had to be restricted to those forms which possess relatively more complicated toothplates than is the case in *Cassidella;* while their walls are always hyaline. The genus *Bitubulogenerina* seems to belong to the **Buliminidae,** and many species, hitherto believed to be true *Bolivina,* were incorporated in that genus. The genus *Uvigerina* was divided into 5 genera. The genus *Globobulimina* is much better placed among the **Virgulinidae,** than in the **Buliminidae.** The genus *Eponides* has been analysed thouroughly, many speces were shown to belong to the genus *Alabamina,* and true *Eponides* was found to be closely allied to *Pulvinulinella.* The genus *Cibicides* has been placed closely to *Parrella,* and the generic names of *Anomalina* and *Planulina* were dropped as being confusing and non-valent. It was proved moreover, that the genus *Cibicides* has nothing to do with *Gavelinella.* Great stress was laid on the homologies of the toothplates of many of the **Biforaminata,** and I suggested, moreover, that the genus *Gyroidina* has nothing to do with *Gyroidinoides,* whereas the genus *Cibicidoides* showed to have been created for dorsally overlapping species of the genus *Discopulvinulina.* The genus *Laticarinina* seems to belong to the group of *Epistomina,* and is no *Cibicides* at all. The genera *Patellina, Patellinoides* and *Patellinella* were dropped, all species having been gathered in the new genus *Discobolivina.* Especially all species, hitherto described as *Discorbis,* were unraveled. An important discovery seems to be, that the umbilical canalsystem of the **Rotalidae** proved to have originated from the protoforamen in that group. For when seen in that light, the problem of the canalsystem becomes much more easily intelligible. In another paper I shall deal with the canalsystem of the **Camerinidae,** which showed to have originated from the toothplate of the genus *Cushmanella.*

I will call attention to the fact, that in a second larger work, on the Foraminifera of the West-Indies, I shall deal with those problems, which could only be touched in this Siboga-Monograph. The two works together will give my views and investigations of the last three years.

I am sure, that these new results, many of which may look astounding, or even unbelievable, will evoke much critic. Yet I am convinced, that my results, based on minute and accurate studies, and critized many times by others and myself, will prove to be of some value for our knowledge of the very important and difficult groups, now analysed. It may be, that several conclusions will show to be erroneous in the end; but I hope, that at least many workers on Foraminifera will be encouraged, to take up more detailed investigations, in the way they have been carried out by Höglund, Brotzen and myself, so that the knowledge, especially on bionomics and on the inner structure may lead to a better and more natural classification of Foraminifera.

THE FORAMINIFERA OF THE SIBOGA EXPEDITION

PART III, DENTATA

BY

J. HOFKER

(1948)

With 348 textfigures

INTRODUCTION

The study of the Foraminifera has revealed that this group of Protozoa shows such a very complicated development in so many different directions, that it cannot be regarded at as a family of the protozoan group, as older authors have suggested. Already Delage and Hérouard, in their Traité de Zoologie concrète, 1896, have called the *Thecamoebida* an "Ordre" of the Classis *Rhizopodia.* In this Ordo they enclose all those fresh-water Rhizopodes, known as *Arcella* and *Difflugia.*

The *Foraminiferae* are looked at as a sub-classis of the *Rhizopodia.* This sub-classis of the *Rhizopodia,* the *Foraminifera,* is devided into several ordines by the authors, and this devision has been maintained by the present author, though he does not agree with the taxonomy, given by Delage and Hérouard, as more recent investigations have discovered many facts unknown to these celebrated zoologists.

There exists a very large group in the *Foraminifera* which is characterised in its more primitive forms by the possession of a toothplate. This group, in which it could be stated that they have been developed from the Jurassic on, and are always connected with one another by intermediate forms, thus forming a homogeneous group, must be looked at as an ordo of the sub-classis of the *Foraminifera.* This ordo has been called by the present author the *Dentata.* It consists at least of three sub-ordines, called the *Protoforaminata,* the *Biforaminata* and the *Deuteroforaminata.* The *Protoforaminata* in each chamber have developed a single foramen, always connected with a toothplate, but for some forms in which the toothplate may be obliterated; the *Biforaminata* show in each apertural face of a chamber two foramina, the one being the protoforamen with its toothplate, the second a newly developed opening, the deuteroforamen. In some forms of these *Biforaminata* the protoforamen may be closed and even totally reduced, and with it its toothplate. The third sub-ordo is that of the

Deuteroforaminata; in that ordo the protoforamen is more or less closed and even may be reduced totally, whereas the deuteroforamen remains as the only foramen existing.

The distinguishing in *Imperforida* and *Perforida,* which is carried through by Delage and Hérouard, as well as by many later authors, cannot be one of real systematic value. Moebius and Rhumbler pointed out already, that some imperforate forms, viz. *Peneroplis* and allied forms, in their initial part show fine pores in the walls, and this was the reason, why Cushman placed this group in the neighbourhood of the *Camerinidae.* The Sub-ordo of the *Arenacidae* among the *Imperforidae* showed to enclose many forms, especially belonging to the *Valvulinidae,* with pores in all chambers of the test, as I could show in this paper. So, this ordo of the *Imperforidae* has no true systematic meaning, and has to be cancelled.

This third part of the Siboga-monograph deals with the Ordo of the *Dentata* only. There are in the material available many other groups, which have not been dealt with in the parts I (1927) and II (1930), but they cannot be analysed here, and will be reserved to a later publication. They include the *Miliolidae,* and several other groups of minor importance. The *Globigerinidae,* which belong to the *Dentata,* have not been treated in this paper, as I intend to deal exhaustively with this family in a paper on the Foraminifera of the West-Indies, in which region the different species of this family are much better developed than in the Pacific area. All those forms, related to what is known as the *Lagenidae,* for the same reason have not been dealt with in this third part. They will be included in a paper, now in preparation, in which the results of the Mortensen Pacific Expedition will be published. These groups seem to have nothing in common with the *Dentata.*

I have to thank for many helps, suggestions and for the donation of important material Prof. Dr. L. F. de Beaufort, now in charge of the Siboga-publications, the Geological Foundation (now Survey) of the Netherlands, with its Director Dr. Th. Reinhold and its paleontological expert, Dr. J. H. van Voorthuysen, Dr. F. Brotzen from the Geological Survey of Sweden, Dr. A. Nørvang, and, not the least, the late Dr. J. Cushman, who gave me many valuable suggestions and sent me from his types. I wish to thank here the late Prof. Dr. M. Weber, who asked me to undertake this large task of analysing the Siboga-material in 1925, whereas Dr. Th. Mortensen from Copenhagen sent to me the large material deriving form his Pacific Expedition and the Ingolf-Expedition and enabled me to compare this large material with that, gathered by the Siboga-Expedition. My friends Dr. W. G. N. van der Sleen and W. de Nobel furnished me with material, deriving from several anchorages in the Pacific, the Red Sea, while I myself gathered material at Rimini and the Gulf of Naples for comparison.

Trimorphism or Dimorphism?

In my works issued before 1933, I have often tried to give suggestions as to the famous problem of Trimorphism. Later investigators likewise have traced several examples of trimorphism among different groups of Foraminifera. As the problem has met with much critic, I have tried to give in this new paper many statistic analyses in regard with this problem. Le Calvez has shown that the reproduction of the Foraminifera may go on along different ways, as in many other groups of Protozoa; in some species an alternation of sexual and asexual generations was traced, in some other species one of these generations has fallen out and only a sexual reproduction takes place; in the best developed reproduction three generations occur, an asexual one, the microspheric generation, followed by several asexually propagating generations, the A_1-forms, whereas at the end of such a series of A_1-forms, the A_2-form gives rise to the forming of flagellogametes which, fusing, give rise to the microspheric generation, the B-form. I may point here to the work by Le Calvez (1938, Arch. Zool. Exp. Gén., Vol. 80 (3), p. 163-333) in which all kinds of reproduction, found in the Foraminifera, are gathered into a single scheme. In *Rotalia flevensis* the wholly developed type of reproduction, the holotrimorphic type, is found; in *Planorbis mediterranensis,* and in *Elphidium* this type is found, together with some simplified types, in which one or more generations are dropped (paratrimorphic type); in *Patellina corrugata* the A_1-generations are suppressed, and the type is called the dimorphic type, whereas in *Discorbis orbicularis* the microspheric form is also suppressed, so that only megalospheric agametes remain (apogamic type).

In case that the reproductive generations of a species may be traced by means of the size of the proloculus, connected with some other characteristics, accessible to analysis, statistic treatise may reveal the state of reproduction of a species. So in this paper I have tried to analyse the different species of which sufficient material was available.

This analysis has given the following results.

Valvulinidae. In no case the material was large enough to statistic analysis. A- and B-forms have been traced in *Listerella minuta, Karreriella bradyi,* and *Valvotextularia stricta,* whereas in *Valvotextularia milleti* all three generations B, A_1 and A_2 were found, but without any statistic analysis.

Bolivinidae. A- and B-forms have been traced in *Bolivina vadescens, Rectobolivina fimbriata, Rectobolivina virgula, Bolivina pygmaea, Bolivina hantkeniana,* probably *Loxotoma amygdalaeformis*; in *Loxostoma karreriana* an analysis gave the suggestion of the paratrimorphic type, whereas the following species showed an analysis, suggesting more or less clearly the holotrimorphic type: *Loxostoma beyrichi, Rectobolivina bifrons, Rectobolivina columellaris, Bolivina robusta, Bolivina compacta, Bolivina albatrossi, Loxostoma cuneatum, Bolivina quadrilatera, Rectobolivina dimorpha.* The results in this family point strongly to the holotrimorphic type, as in those cases in which only the A-form or A and B could be traced, this must be owing to lack of larger material, whereas only in the species *L. karreriana,* a highly developed species, the typical paratrimorphic type was found.

Conorbinidae. In *Amphistegina radiata* a large amount of young specimens was analysed, and holotrimorphism was clearly shown. The same result was obtained in *Asterigerinata mamilla,* but for the fact, that the A_1-generation was doubtful, and that it is very probable, that here the dimorphic type is found; this result agrees with that, found by Meyers in the related species, *Discobolivina corrugata* (*Patellina*). In *Discopulvinulina pseudolobatula* the holotrimorphic type of reproduction was clearly shown by the statistic analysis. In *Gavelinellopsis* the three generations were found, and an analysis will show probably the holotrimorphic type of reproduction. In *Discobolivina inconspicua* A- and B-forms were traced, but no analysis could be given. In *Streblus beccarii, S. batavus* and *S. turgidus* the analysis points to the dimorphic type of reproduction, as no typical difference between A_1 and A_2 was shown (see also my paper on the West Indian Foraminifera).

These results point to the supposition, that in the *Conorbinidae* the original type may have been the holotrimorphic type, but that in many species the type has become altered, as some generations have been suppressed, especially the A_1-form. Thus in this group many species show the dimorphic type of reproduction, and this fact has given rise to the supposition, that in all Foraminifera the reproduction would go along the dimorphic type, as many species are belonging to this family, which occur in recent gatherings abundantly. In the recent species of the *Globigerinidae,* also belonging to this family, the dimorphic condition is once more reduced into the apogamic type, as an analysis has shown; but I found too, that in Cretaceous species the dimorphic type is present in this genus. So we can state, that the holotrimorphic condition is the more primitive condition, whereas the paratrimorphic, dimorphic and apogamic conditions are types, which have resulted from suppression of one or even more generations in course of time. This result is in agreement with modern views on reproduction as well as with the results, obtained in other groups of *Protozoa.*

In the *Valvulineridae* and in the *Tinoporidae* the state of reproduction is that of the holotrimorphic type, as I have shown already in several instances; but in the cretaceous *Sporadotrema macroporus* conditions are not yet cleared up (may be that the B-form is lacking).

Ceratobuliminidae. In *Lamarckina* the reproduction seems to be of the dimorphic type, though results are not yet sufficient. In *Epistomina* no good results have been obtained; yet three forms could be traced. The same can be said about *Laticarinina pauperata.* Here facts point to a suppression of the A_1-form (dimorphic type). In *Ceratobulimina pacifica* holotrimorphism was clearly shown, yet the two curves of the A-generations were somewhat overlapping, so that a tendency to paratrimorphism was shown too. In *Robertinoides* and *Pseudobulimina* the material was not large enough to trace the reproductive conditions. In *Alabamina verrucosa* holotrimorphism was traced down, but in *Eponides calida* dimorphism seems to occur. In *Parella culter* A- and B-forms were stated, but the material was not large enough to give a statistical analysis. In *Cibicides* holotrimorphism seems to occur, yet no statistic treatment is available.

The *Ceratobuliminidae* seem to be in the same labile condition which is found in the *Conorbinidae* in respect to reproduction. Yet here too facts point to holotrimorphism in the more primitive forms, dimorphism and apogamy in the more developed species.

In fossil (cretaceous) *Buliminella ovula* the species seems to be dimorphic throughout; *Buliminella elegantissima* on the other side seems to be trimorphic, though no statistical analysis was made. Yet an analysis, given by Höglund (Zool. Bidrag Uppsala, Vol. 26, 1947, p. 217) does not show trimorphism. So in this family the state of reproduction is not yet cleared.

In the *Uvigerinidae* holotrimorphism was found in *Angulogerina oligocaenica,* A- and B-forms were found in *A. angulosa,* while *A. tricarinata* shows true holotrimorphism. A and B were moreover found in *A. occidentalis,* and in *Alluvigerina pygmaea.* In *Neouvigerina ampullacea* true holotrimorphism was stated, whereas in *N. porrecta* it was not clear, so that here may lay an instance of paratrimorphism. In *Euuvigerina mediterranensis, peregrina* and *pygmaea* true holotrimorphism was made very probable, as in *E. aculeata.*

So we come to the conclusion, that in the *Uvigerinidae* most species show holotrimorphism, some a slight indication to paratrimorphism. True dimorphism could not be found.

Among the *Cassidulinidae* material available showed, that in lower-cretaceous *Pleurostomella alternans* true trimorphism occurs. In *Ehrenbergina pacifica* A- and B-forms were found, as was the case in *Cassidulina subglobosa.* In *Cassidulina laevigata* three different generations, B, A_1 and A_2 were found, but statistical analysis could not be made as yet. In *Cassidulinoides* holotrimorphism was clearly shown.

All these data point to holotrimorphism in the whole group of the *Cassidulinidae.*

When we compare these data about the reproductionnary conditions of the different families of the *Dentata,* we come to the conclusion, that especially those forms, in which fine protopores are found, the type, called by Le Calvez holotrimorphism is a rule. These forms with fine protopores are the more primitive forms too. This leads once more to the conclusion that holotrimorphism is the primitive stage of reproduction. On the other hand, many species which show a more advanced stage of development, or are surely species which show advanced adaptions to special conditions (*Discobolivina, Globobulimina, Globigerinidae,* etc.) show a reproduction-scheme which is dimorphic or even apogamic. This leads to the conclusion, that these schemes of reproduction are derivated types.

The foramina

I call all those larger openings, through which the main part of the protoplasm is streaming toward the outer world, and which always are situated at the distal wall of an end-chamber, foramina; for these openings are characteristic for the Foraminifera. When a new chamber is added, the former foramen is situated in the septum between the former chamber and the new one; I call these foramina septal foramina. The last-formed foramen is often called the aperture, also in this work.

In the toothplate-Foraminifera in more primitive forms the foramen is connected with a toothplate. This toothplate may be very short, and then, when the foramen has become septal foramen, it does not run through the lumen of the chamber (*Valvulinidae*). But in many higher developed forms the toothplate is so large, that it runs through the chamber and is connected with the next foramen (or aperture). In those forms it is always attached to the proximal wall of the next foramen. In those forms with such a large toothplate, this plate seldom is formed at the aperture before the next chamber is built. But this is the case in *Lamarckina,* where it forms a covering plate over the umbilical cavity, and in *Asterigerina.*

All those foramina which are at the inner side connected with a toothplate, running in the last-formed chamber from the septal foramen to the next one, I call protoforamina. Many forms show but protoforamina. They are gathered as *Protoforaminata.* A typical form of a protoforaminate Foraminiferum is the genus *Bolivina.* It never shows any tendency to form other foramina than protoforamina.

Some forms develop extra openings, more or less connected with the protoforamen, but always formed by peculiar folding of the attached part of the toothplate (some higher developed *Buliminae,* the genera *Robertinoides, Pseudobulimina, Cushmanella*). These secondary openings, formed by the toothplate, and always connected with canals in the toothplate, are called supplementary foramina.

In many forms of the coiled toothplate-foraminifera a second opening at the apertural face is developed, not connected with the toothplate which runs through the chamber, at which apertural face the opening is found. They have been developed in many *Ceratobuliminidae,* and are seen in Brotzen's new genus *Höglundina* (formerly *Epistomina*). These openings, often found together with the real protoforamen, are called here *deuteroforamina.* They form the septal foramen in those genera and species, in which both kinds of foramina exist together (*Biforaminata*), whereas the protoforamen never forms a septal one. They are found too in the *Conorbinidae.* But the toothplate often originates near the border of this deutero-septal-foramen. It is, however, never really attached to the border of the next one, but always runs to that of the protoforamen.

In highly developed genera of the coiled type, the protoforamen is reduced, and even may be totally absent. Then the deuteroforamen takes over the functions, formerly discharged by the protoforamen. It forms the larger opening to the outer world. In those forms, the toothplate is reduced or totaly absent also (*Deuteroforaminata*).

In other forms the protoforamen alone remains, whereas a deuteroforamen never existed or has been reduced. Yet here too the toothplate may reduce and only the place of the protoforamen may point to its real origin. This has obviously been the case in the genera *Parrella* and in *Siphoninella* and *Siphonina.*

Brotzen has given names to the situation of the foramen and does not give attention to its real origin. So he distinguishes areal, sutural, marginal, lateromarginal apertures. This is not a very lucky distinction, as the homologies do not become clear in this way. So, the ventral and sutural protoforamina of the *Conorbinidae* and the lateromarginal openings of the *Epistominidae* are homologous foramina; but in Brotzen's description this is not made clear. I do not follow Brotzen's descriptional names, as they do not give us any idea to the real origin of a foramen. Brotzen's distinctive names are very useful when one has to indicate the situation of a foramen; they give a much more exact position and a much shorter description of this position, than those, used formerly. So they can be used further on; but they must not pretend to be names of the foramina themselves, for they are only names for their situation.

The septal foramen

(Fig. 1)

In all those forms in which there is only a single foramen, the protoforamen (*Buliminella, Bulimina. Bolivina,* etc.) in the *Protoforaminata,* the septal foramen is formed by the protoforamen. As the toothplate is attached proximally as to the next protoforamen and distally as to the former one, a septal foramen when seen from the next chamber, always shows the toothplate attached more or less marginally in coiled specimens.

When this is true, in *Protoforaminata* the toothplate is found marginally from the septal foramen. In forms as *Bolivina* this is not at once clear, as here the chamber is turned round at an angle of 180°, so that the marginal border of the chamber is always more or less turned toward the axis. But in those species, in which the coiling is such, that more than two chambers form a whorl, the marginal and axial difference is clear enough.

This is, however, not so clear in the genera *Conorbis* and *Discobolivina,* in which the septal foramen is found in the basal chamberwall and here the toothplate is surrounding the foramen more or less. Here the septal foramen is found at the base of the pillar-like toothplate, and the toothplate is attached axially at the wall of the chamber.

In all those species in which two foramina exist together, for instance in *Epistomina* and *Robertinoides,* the protoforamen is found more axially to the toothplate, whereas the deuteroforamen is found more marginally. This is not to be confounded with the fact, that in *Epistomina* the protoforamen is a marginal foramen, whereas the deuteroforamen is a sutural one. When considering the situation of the toothplate, the protoforamen is found always near to the axis of coiling, the deuteroforamen more on the opposite direction in regard to the toothplate.

When considering these facts, one observes, when studying transverse sections of tests, that as a rule the septal foramen is found in *Protoforaminata* axially from the toothplate, in *Biforaminata* the protoforamen is axial, the deuteroforamen marginal in respect to the situation of the toothplate, whereas in the *Deuteroforaminata* the septal foramen is found marginally from the toothplate. Consequently in those *Deuteroforaminata,* in which the toothplate is obliterated (*Cibicides* e.g.) the septal foramen will have the tendency to become marginal, whereas in those forms in which the septal foramen in reality is a protoforamen, the septal foramen will have the tendency to be situated in the ventral half of the chamber (*Alabamina, Gyroidina, Eponides*). (See fig. 1).

A closer study in this way reveals that in all those forms, in which the protoforamen is reduced and the deuteroforamen has taken over its functions, as is the case in *Discopulvinulina* and *Neoconorbina,* the septal foramen is found marginally from the toothplate. In those forms, in which obviously the protoforamen is functioning as septal foramen, the septal foramen is found axially to the toothplate.

A basal foramen thus is found in all those species which are *Protoforaminata,* such as *Bolivina, Buliminella, Bulimina,* and furthermore in *Conorbis* and *Discobolivina.* Here it is not clear at once, whether the situation of the septal foramen is more axial or more marginal in respect to the toothplate.

In the genera *Discopulvinulina, Neoconorbina, Streblus* and *Asterorotalia, Cymbaloporetta* and *Discovalvulineria,* the septal foramen is clearly marginally placed in respect to the toothplate; here we have a typical deuteroforamen, functioning as septal foramen. The same can be said of *Laticarinina*; here the protoforamen is totally reduced.

In the genera with two apertures, *Epistomina* and *Robertinoides,* the septal foramen is formed by the deuteroforamen, as its connection with the toothplate clearly shows, and it is situated marginally from the toothplate.

But in the genera *Alabamina, Parrella, Gyroidina* and *Eponides,* in those cases in which a reduced toothplate is found up, the septal foramen always is found axially from the toothplate. This indicates, that the septal foramen is a protoforamen, and that consequently in these species with a simple aperture, the aperture likewise is a protoforamen. This would suggest that the depression on the apertural face of *Alabamina* is not, as authors have supposed, a reduced protoforamen, but nothing but the toothplate itself forming part of the apertural face, as in *Buliminella.* This coincides with the fact, that in *Alabamina* and allied genera the apertural face here is poreless.

In those forms, in which the protoforamen is closed by a special plate forming in some forms secondary chamberlets at the ventral side, the situation of the septal foramen in respect to that of the toothplate indicates, that the septal foramen here is the deuteroforamen as well (*Asterigerina, Asterigerinata, Amphistegina*).

So the study of septal foramina gives us some clues to the taxonomy of species and genera.

The place of the septal foramen in respect to the sutures is not of so high a valuable importance in taxonomic respect. For this place in respect to sutures is mainly conditioned by the speed of coiling of the test and the overlapping of the chambers. In some species of a genus this overlapping and speed of coiling is a high one; then the septal foramen will be often found in the middle of the back wall of the chamber; in other species of the same genus this overlapping may be not so strong; in that case the septal foramen will be found more or less sutural.

Of much more generic value is the place of the apertural foramen; for I found, that in most cases the deuteroforamen is formed by the sutural border of the proximal chamberwall, and conse-

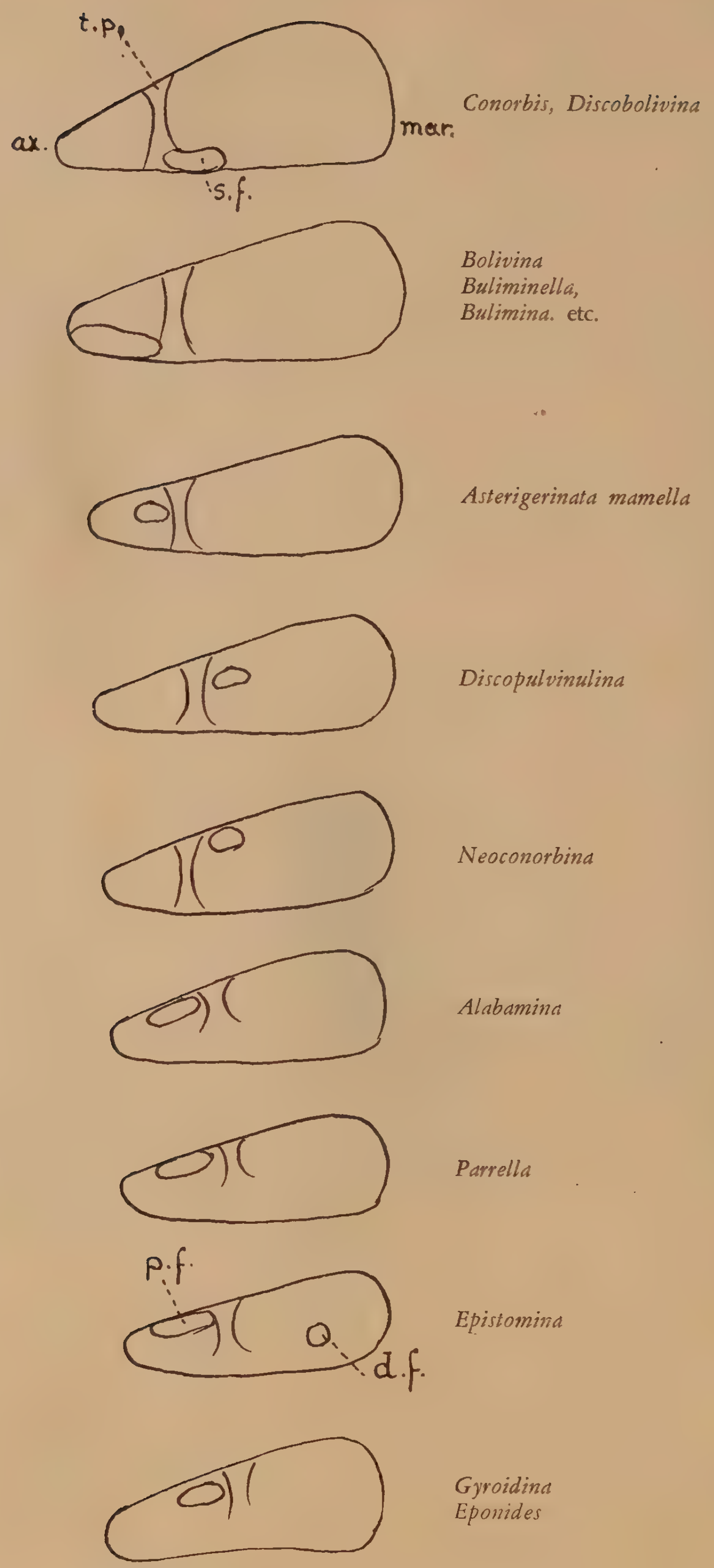

t.p.
ax.
mar.
s.f.
Conorbis, Discobolivina
Bolivina
Buliminella,
Bulimina. etc.
Asterigerinata mamella
Discopulvinulina
Neoconorbina
Alabamina
Parrella
p.f.
d.f.
Epistomina
Gyroidina
Eponides

Fig. 1. Schematic figure showing situation of the septal foramen in respect to the toothplate. ax.-axis of test; mar.-marginal side of chamber; p.f.-protoforamen; d.f.-deuteroforamen; t.p.-toothplate; s.f.-septal foramen.

quently this foramen is always more or less sutural. The protoforamen often becomes more or less detached from the sutural border. This detachment is clearly shown in those bolivine forms, in which the biserial arrangement of the chambers is altered into a uniserial arrangement. Then the protoforamen becomes more or less detached from the suture, or areal, as Brotzen has called it. This is also the case in *Höglundina* (*Epistomina*), in which the protoforamen is so strongly removed from the suture, that it is situated marginally. A detailed study of the situation of the aperture thus may lead to differentiation into genera, and Brotzen has tried succesfully in that direction. But such an analysis will give good and valuable results in only those cases, in which further analysis of the inner structure, especially of toothplates, when existant, have cleared up, whether an aperture is a protoforamen or a deuteroforamen. When we cannot undoubtlessly say, whether an aperture is a protoforamen or a deuteroforamen, all speculation about its generic value will fail more or less, as no homologies can be traced in that case and one does not know, whether an aperture of one species, compared in situation with that of another species, is homologous with that aperture or not. In this way it is intelligible, that e.g. *Gyroidina* and *Gyroïdinoides, Cibicides* and *Cibicidoides, Reinholdella* and *Discorbis,* have been thrown together, while in reality they are belonging to quite different and remote groups.

The pores

Very little attention has been given by authors to the shape, the situation and the structure of the pores. Yet these characteristics are of immense systematic value.

Fine pores have been found in many species of the *Valvulinidae.* They are situated between the sand-grains, forming the agglutination of the walls. They are primitive openings in the walls, and thus will be called in this paper *protopores.*

When considering the different species of a genus one often observes, that older species show fine pores, whereas geologically younger species show coarser pores. This phenomenon could be observed in the genus *Bulimina,* in which the older species, such as *Praebulimina* and several typical cretaceous *Bulimina* species, show fine pores all over the surface. Some genera maintain those fine pores even up to recent times (*Buliminella, Cassidulinidae*), whereas other genera show the tendency to get coarser pores during time. This is clearly shown in *Bulimina,* in which *Bulimina trigonalis* shows fine pores in the initial part, whereas younger chambers show somewhat coarser pores. In *Bolivina* the proloculus always shows fine pores, whereas many more recent species show coarse pores in all later chambers. In the genera of the *Uvigerinidae* the fine pores are maintained in all groups. All those forms with very fine pores thus are more or less primitive forms, whereas often forms with coarser pores are more recent types, or more advanced types.

But the instances given above of coarser pores always show that these pores are yet protopores. They begin at the inner side of the wall with a single opening, which is a rounded one. Even in *Globobulimina,* in which elongate pores have developed, these pores at the inner side show a rounded opening.

The same phenomenon which is found in all those forms cited above (*Protoforaminata*), showing the tendency to develop coarser pores in the course of time, is stated also in many trochoid forms, hitherto known as the "*Rotaliformes*". In primitive species of *Conorbidae,* such as Jurassic and Cretaceous *Conorbis* and *Reinholdella,* the pores are extremely fine. But higher developed genera, such as *Asterigerina* and *Asterigerinata,* develop much coarser pores. Yet these pores are protopores as well. But in some groups the thickening of the walls by secondary chalk-layers surrounds groups of protopores, which consequently open into a single larger opening, formed by the secondary thickening. These pores, when seen from the inside of the wall, often reveal their real structure, as here a fine porous plate is closing the larger opening. These much coarser pores have been called *deuteropores* in this work. They are found in many more speciallised genera, such as *Discopulvinulina, Cibicides, Tinoporidae, Cymbaloporetta,* etc. They have been developed too in speciallised forms of the *Valvulinidae,* such as *Valvobifarina mackinnoni* and *Valvopavonina.* In these forms the proloculus shows the fine protopores. Deuteropores always have a diameter larger than 2 μ, and often show an irregular shape (*Cibicides*).

In some cases (*Asterigerinata, Asterigerina, Eponides,* etc.) large more or less rounded openings have been found in the toothplate or in the buildings, formed by the toothplate. These openings, or pores, have been called toothplatepores. They have nothing to do with the pores in the walls, and always are much larger than protopores.

The situation of the pores is, as has already been mentioned, of high taxonomic value, as in all cases observed this situation is a quite constant one within a species.

In many real *Virgulina* the part of the chamberwall bordering the aperture is lacking pores. This may be an indication, that this part is formed by the poreless toothplate, especially by its attached part. This is without doubt the case in *Buliminella.* It may be, that in many species of *Bolivina,* in which poreless parts of the chamberwalls, always situated bordering the aperture, are found, likewise these parts are formed by the toothplate. When, in *Bolivina,* poreless parts of walls are observed, they always are found distally, never proximally. In some species only a single row of pores is found, situated near to the proximal suture (*B. spinescens*); in those cases the pores are coarser than in species, in which the whole wall is pierced by them. In many species with thick walls the pores are larger than in those with thin walls. This too is a remarkable fact, leading to the supposition, that the pores have to do with respiration. So, in cretaceous species of *Globigerina* pores are rather fine, whereas in recent species they often are very coarse ones; the walls of cretaceous species are much thinner, than those of recent species with coarse pores; in recent species with fine pores, the walls are always very thin. But a remarkable refutation of these facts is found in the *Camerinidae;* in that group, descending from thin-walled *Cushmannella* with very fine pores, the pores are always fine ones, though often walls are rather thick.

Notion must be given to the ornamentation of the walls in respect to the situation of pores. It often occurs that walls are thickened at special localities; this is very beautifully seen in the ornamentation of the *Uvigerinidae,* in which always very fine pores occur. In those places, in which secundarily costae or knobs are formed, the pores draw aside. In those forms where larger pores occur, often those pores are surrounded by thickenings of the wall; this is found in many higher speciallised forms, and give the suggestion that those larger pores have not only to do with respiration, but also give way to protoplasm carrying dissimilates.

Jn many species of *Bolivina, Buliminella* and *Virgulina* the pores are lacking on distal parts of the walls. This is a very constant character, and thus of specific value. In species of the *Conorbidae,* it often is found, that whole groups of species show pores either at the ventral, or at the dorsal side, while the other side is lacking pores. This fact also is of high systematic importance. I found, that in primitive *Gavelinella* from the Lower Cretaceous (*Gavelinella intermedia)* the pores are lacking totally on the dorsal side; they show moreover protopores; in later species, such as *Gavelinella baltica* form the Upper-Cretaceous, the pores have become deuteropores, according to the rule, that more developed species in a genus often show larger pores; but here too the dorsal side is lacking pores. Species of the genus *Parrella* on the contrary show the tendency to develop pores on the dorsal side, and not on the ventral one; this tendency is shown in the descendants of *Parrella, Cibicides* and *Siphonina*; here the pores are mainly developed on the dorsal sides. But in those species, in which the dorsal side is covered by thick layers of secondary chalk, the pores may develop mainly on the ventral side.

As I have already pointed out, protopores never develop on the toothplate; this is obvious enough, as protopores, being structures having to do with respiration, have no value in a toothplate, totally surrounded by protoplasm. So, a plate covering the protoforamen, and provided with protopores, as is found in *Reinholdella,* cannot be a toothplate; but lips in connection with the protoforamen, lacking totally any development of pores, may be regarded as a lengthening of the toothplate; those lips have been found in all degrees of development in the genus *Discopulvinulina.* Such lips have been found too in those cases, in which a real toothplate has been lost (*Gavelinella, Valvulineria, Globotruncana,* etc.). So, it may be, that those lips in forms, lacking any trace of an inner toothplate, may have derived also from a toothplate, are nothing but the remains of a toothplate. There is a lip, covering partly the umbilical cavity in *Ceratobulimina*; this lip shows protopores, so it cannot be connected with a toothplate; closer examination of the structure of its toothplate has shown, that in *Ceratobulimina* this covering lip is part of the outer chamberwall, and not of the toothplate; so it is not homologous with the covering plate of *Lamarckina* or of *Cancris* (this plate in the latter species is lacking pores and thus may have derived from a toothplate).

Keels in Foraminifera are not at all homologous buildings. In *Siphonina* often very heavy keels are found; they always are pierced by deuteropores, and obviously formed by the outstreaming protoplasm from these rows of pores. In *Laticarinina* I showed, that the keel is formed by the successive toothplates. In many closely allied forms of the *Marginolamellidae* the poreless keel stands in connection with the poreless part of the ventral and apertural wall of the chamber. This connection, very clearly shown in *Globotruncana* and *Globorotalia,* suggests that this keel too has been formed by the outgrowing toothplate, when one is convinced that the poreless ventral and apertural parts of the chamberwalls, as in *Buliminella,* are formed by parts of the toothplates. *Laticarinina* shows a typical instance for this view. Thus, when considering the pores of a species, it is of much value to discover, if the margin of the species is porous or poreless. In the latter case the species may be closely allied to those species, gathered here in the family of the *Marginolamellidae.* Already in many species of *Discopulvinulina* this poreless keel is found, and here too the poreless lip and the poreless ventral side stand in connection with this poreless keel. Obviously the *Marginolamellidae* have to do with the genus *Discopulvinulina.*

All these facts point to the high value of the study of the pores as generic and specific characteristic. Many species of the genus *Cibicides,* so difficult to analyse in its species, can easily be distinguished from each other by means of the place of the deuteropores; some species lack them constantly on the ventral side; other species have them placed on the ventral, as well as on the dorsal side; some ones have the pores at the ventral side smaller than on the dorsal side, etc. Even the diameter of the pores is a specific characteristic, as I could show in the genera *Bulimina, Cibicides, Discopulvinulina, Neoconorbina* and *Globigerina.*

The material

Most of the samples, deriving from the Siboga-expedition were rest-samples, and often very poor rests too. There were very few mud-samples left and so the samples of the Siboga itself were of less use to the study of Foraminifera. But together with the Siboga-samples those from the cable-ships Van Gogh and Telegraaf were sent to me, and these samples showed to be of high value. H.M. Van Gogh dredged in the Mentawei-basin, south of Sumatra, whereas H.M. Telegraaf obtained many samples from the neighbourhood of Flores. Together with this material some samples of anchor-mud were made by Dr. W. G. N. van der Sleen and kindly sent to me, and some other samples were added deriving from the Pacific-Expedition by Dr. Th. Mortensen from Copenhagen. I wish to thank both for their kindness by giving to me full freedom to dispose of their material.

In several cases I compared my results with material from other regions of the world. They came from the following localities: Bay of Naples, the beach of Rimini, the beaches of Holland, some samples of the Northern Atlantic, deriving from the Ingolf-Expedition, the West-Indian region, especially from the former danish isles, deriving from Mortensen's Pacific expedition, some samples from the coasts of Peru and Chile, kindly gathered by my friend De Nobel, and some samples from the Irish coast, deriving from the Earland-collection, kindly given to me by Dr. J. H. van Voorthuysen, and several samples from the Red Sea and the Gulf of Aden, collected by Dr. van der Sleen.

To this material were added many samples of fossil localities, kindly set to my disposal by the Geological Survey of the Netherlands, deriving from the drillings by the Rijksopsporing van Delfstoffen, for which very rich material from the Tertiary and Cretaceous, as well as from Jurassic strata, I have to thank the leader of the Survey, Dr. Th. Reinhold, and the micropaleontologist in charge, Dr. J. H. van Voorthuysen.

For comparison, Dr. F. Brotzen, Dr. J. A. Cushman and Dr. A. Nørvang have sent to me many specimens from recent and fossil localities, for which kindness I am very thankful. Especially Dr. J. A. Cushman, Dr. Brotzen and Dr. J. H. van Voorthuysen helped me through many difficulties with their criticism.

Types of most of the species have been deposed in the Zoological Museum at Amsterdam, in which the Siboga-collections are stored. Some duplicates of more common species, especially those from samples not collected by the Siboga-Expedition, have been stored in the Geological Survey of the Netherlands. In both collections the specimens have been mounted in the usual slides in dry state. No sections have been spared.

Methods

The rough samples have been sieved with plancton sieves of different largeness, so that tests of different size could be separated. It was found, that many species in such a way can be separated from each other, and that often in a single species the different generations were separated in this way.

The tests were picked out from the sieved samples by means of a fine and pliant needle, dipped into ricinic-oil, and have been mounted on glass-slides with a drop of ricinic-oil. In some cases this oil was heated to drive out air-bubbles, but in most cases this was not necessary, as within a few days the oil has dissolved the air totally. In this oil tests become very translucent, and often enclosed rests of protoplasm are dissolved too. Many details of the inner structure can be observed, especially in higher magnification.

The magnification used was from 40 × to 630 ×. In most cases a magnification of 480 × showed to be best.

Tests were always drawn in different directions; when the oil was too thin to give a test a situation wanted, the tests were removed into Canada-balsam which had to be hardened on a stove. For this purpose an electric stove was used with constant temperature of about 80° C. There is no difficulty in removing tests from ricinic-oil into Canada-balsam, as the oil diffuses easily with the balsam.

When, for mounting or other purposes the test should be dry again, the slide with oil was laid on a watch-glass, filled to the border with benzene or xylolum; the oil dissolves in the medium and the tests sink to the bottom of the vessel. After washing them once again with the medium, they can after drying be picked out and mounted on a slide with glue.

No species was studied without making sections of it. Even the most fragile and small objects can be ground on a fine limestone from Solnhofen with the aid of ricinus-oil on the stone, and mounted in hardened Canada-balsam. Some objects were mounted in paraffine. The adhering ricinic-oil in the object makes the Canada-balsam less splintery. Even in cases in which very few material was available, the tests were, after drawing them with a mirror, ground down, so that in those cases the object was lost, it is true, but often very important knowledge was obtained.

In many cases the inner structure, especially of the toothplates, was so difficult to analyse, that even thin sections were not successful. In those cases the whole test was ground down, and after each two or three grinding-movements a drawing was made of the surface of the preparation. Accidental uncleannesses in the preparation could be used as fixed points of the successive drawings, and later these drawings were traced on glassplates, for which purpose were used photographic plates. The surface of the plates was cleaned first, and then the drawing was made with china-ink. The successive plates were mounted one after another in a grip, and in this way one is able to observe all inner structures wanted, especially, as parts of the set of plates can be removed or seen from the back side. In this way many new and important structures could be observed, and often a very good idea could be formed of the inner structure (*Epistomina, Cushmanella, Robertinoides, Pseudobulimina, Ceratobulimina*; see also the paper on West Indian Foraminifera).

In case a large material of a species was obtained, statistic study was made of the species. It was found that for this purpose the following data are of importance: size of whole test; total number of chambers; number of chambers in last-formed whorl; inner diameter of proloculus. In some cases other data, as the occurrence of pustules on the surface, the amount of secondary chalk, etc., may be added, or the peculiar shape of the end-chambers. When with these data a diagram is made, one often is able not only to analyse the averages of several important measures of the species, but also the range of variation, so that these ranges can be added to the description of the species. In many cases it was moreover possible to indicate the different generations in which the species was found. It was shown in this way, that many species occur in three distinct generations, and that other species, often belonging to special genera, show only two of them. The three generations have been called, as usual, B, A_1 and A_2.

Special attention was given to the geographic distribution of the species. With these finer methods it was possible to indicate different species in different areas, in which with the rougher methods only a single species hitherto was believed to exist.

As I observed for the purpose of genetic study many fossil species, I could show, that all these methods can be used too for fossil species, even of Jurassic strata.

ORDO DENTATA

A large series of Foraminifera shows a very peculiar character, the toothplate. In many primitive genera of the group this toothplate is nothing but a valvular plate attached to one of the borders of the aperture and does not extend in the lumen of the next-formed chamber. In these primitive forms, hitherto gathered under the family-name of the *Valvulinidae,* this plate is attached to the proximal side of the aperture. It seems to be in its primitive function a protecting plate to the opening of the aperture, though in several attached species of the *Valvulinidae* the plate already may have had a function connected with this attachment.

The walls of the *Valvulinidae* have mostly been described as "arenaceous". But a closer examination of those walls revealed to me the amazing fact, that they possess typical pores, like those of many calcareous tests.

Pores were already known in textularian tests in *Textularia stricta* Cushman, in which species I described them in 1933 (Vidensk Medd. fra Dansk naturh. Foren, Bd. 93, 1932-33, p. 80, fig. 4). I could detect these pores too in several other species, belonging to the textularian group, such as in *Karreriella bradyi, Clavulina nodosaria, Valvotextularia candeiana, Valvotextularia catenata.* These pores, which can easily be seen between the sand-grains in the test in a clarifier, are especially common in many members of the *Valvulinidae.*

In some forms which, according to the arrangement of the chambers, are connected with the *Valvulinidae,* the original plan being always coiled, mostly in triserial arrangement, the toothplates are obliterated and the walls are totally calcareous, the amount of sandgrains becoming more and more small. Such forms may be those, hitherto known as *Bolivinita* from the Cretaceous, *Pavonina* and some species gathered in the genus *Bifarina.* They always show a rough surface of the walls, and not the smooth one, found in real calcareous Foraminifera.

From primitive *Valvulinidae,* such as the genus *Valvulina,* may have developed in the Trias or in the earlier Jurassic period many groups of real calcareous Foraminifera, always characterised by a toothplate attached to one of the borders of the aperture, which toothplate, now having obtained obviously a new function, more and more projected from the aperture. These primitive forms may have been of the nature of *Lamarckina,* possessing a single aperture, always connected with a toothplate. The triserial arrangement of many forms of the *Valvulinidae* has been maintained in those primitive forms of calcareous species, which are now known as the *Buliminellidae.* From this group many genera have developed, such as *Bulimina* and its allies, probably *Virgulina* too.

Many genera of the *Valvulinidae* show a textularian arrangement of chambers, and from those forms may have arisen the genera, now belonging to the *Bolivinidae,* which family is an ancient one, as typical *Bolivina* occurs in several species already in the Dogger and Lias.

The condition of the toothplate in most of those offsprings of the *Valvulinidae* altered, when the plate was built up after or together with the building of the next chamber. In all those forms however the original place of the toothplate, attached at its base at the proximal border of the former aperture, was maintained. But it was in those higher forms also attached to the marginal, dorsal or distal border of the next aperture, its function obviously becoming one of attachment to more dense protoplasm in connection with attached or creeping life.

This primitive and single aperture, found in so many more primitive forms, *Bolivina, Bulimina, Uvigerina, Lamarckina, Conorbis,* I have named in this paper the protoforamen. It is in those forms, in which the toothplate is developed, characterised by its distal border attached to the former, and its proximal border attached to the next toothplate. This development of the toothplate indicates the structure of the test too, this being always triserial or biserial in origin.

It may be, that the important ancestral genus *Conorbis* derived directly from coiled *Valvulina* itself.

Many species, more developed than those primitive protoforaminous species, have developed a second foramen, which foramen may have been in origin the opening, through which the digesting protoplasm streamed, as the protoforamen gave opening to the attaching protoplasm. This second foramen, clearly from now on formed the septal foramen, as the stream of digesting protoplasm has to reach the former chambers too. This deuteroforamen is found in many species together with the protoforamen, in genera such as *Discopulvinulina, Streblus,* and its descendants, and in *Epistomina.*

It is also found in *Cushmanella, Robertinoides,* etc. together with the protoforamen, and, consequently, though altered into a marginal chord canal system, in the *Camerinidae.*

In several groups the protoforamen is closed, when the deuteroforamen developed. So in *Reinholdella,* and its offsprings, *Asterigerina* and *Amphistegina.* In *Asterigerinata* it has been closed by a special outgrowth of the toothplate, but in *Streblus* and allied genera it forms the umbilical canalsystem.

In many higher forms of *Epistominidae* the protoforamen is closed by secondary chalk, as seems to be the case in *Laticarinina.*

Several species of *Discopulvinulina* show a gradual reduction of the protoforamen, and this reduction has become a total one in all groups deriving from and including *Valvulineria.* In this large group only the deuteroforamen has remained; in the genus *Alabamina* this closing of the protoforamen has already become a fact, and in many allied genera, such as *Gyroidina* and *Eponides,* the reduction is a total one, as the attached toothplate has been obliterated too.

In this way a taxonomical revision has been undertaken in this work, based on the knowledge of a very characteristic structure, hitherto nearly overlooked, and often wrongly interpreted, the toothplate. As in all those genera and families, in which the next chamber is built before or together with the toothplate attached to the former aperture, this toothpate is formed within the protoplasmic body, and thus not exposed to outward circumstances. So, while often species vary due to different surroundings, the toothplate remains unaltered. Moreover, as has been shown in modern time, the different generations of a species often differ too in characteristics, the toothplate invariably maintains its constant character. In this way the toothplate is a much more reliable characteristic than the texture of the outer walls.

While the structure of the toothplate may differ in different species of a single genus, it always shows typical generic characteristics, so that often a whole genus may be characterised by the toothplate. In the genus *Cassidulina* the toothplate shows a primitive shape, with a very simple free folded part, whereas in the genus *Bulimina* in most cases it shows a much higher development. In the species of the genus *Epistomina* the toothplate always is of a rather simple structure, with a highly developed free folded part, whereas in the genus *Lamarckina* the toothplate lacks its folded part. In the genus *Conorbis* and the closely related *Discobolivina* the toothplate is pillar-shaped, whereas in the genus *Asterigerina* it always is a horizontal plate, lacking any trace of a free folded part. In the genera *Robertina, Robertinoides* and *Pseudobulimina,* three closely allied genera, the toothplate shows a very complicated structure, reaching its most higly development in the genus *Cushmanella.*

But not only a genus is characterised by its toothplate in its most typical characteristics, but the relation of different genera can be found when studying the toothplates. The toothplate of *Cassidella, Virgulinella* and *Pleurostomella,* though differing in minor characters, is in more important features so uniform, that one does not hesitate to look at those genera as closely related. This is the case too in many of the *Conorbinidae,* though belonging to quite different genera. Toothplates of *Uvigerina, Angulogerina* and *Siphogenerina* betray at once their relationship, but the development in the different genera of the *Uvigerinidae* shows us that one genus is more closely related to another genus, than a second one.

So the knowledge of the toothplate is of very great importance to our knowledge of the systematic place of species, genera and families. Moreover it gives us a very important character as to distinguish the species from each other. Specimens, deriving from quite different areas or regions of the world showed to be identical in regard to their toothplate, notwinthstanding the outward characteristics of the specimens were differing from each other due to different circumstances. Specimens which showed outwardly no difference at all (*Virgulinae, Bolivinae*) showed to belong to quite different species according to the difference of their toothplates.

It was in respect to these discoveries, that I gave special attention to the structure of the toothplate, together with the apertural characters. There is, however, a third feature, which can be used as a very reliable character, which has been too often overlooked. That character is the shape, size and situation of the pores. It was found, that the primitive condition is to possess very fine pores occurring all over the surface of the walls. These fine pores have been called in this paper protopores. In many species, in which in later chambers the pores become large and scattered over the surface, the initial parts show to possess the primitive conditions: fine protopores all over the surface.

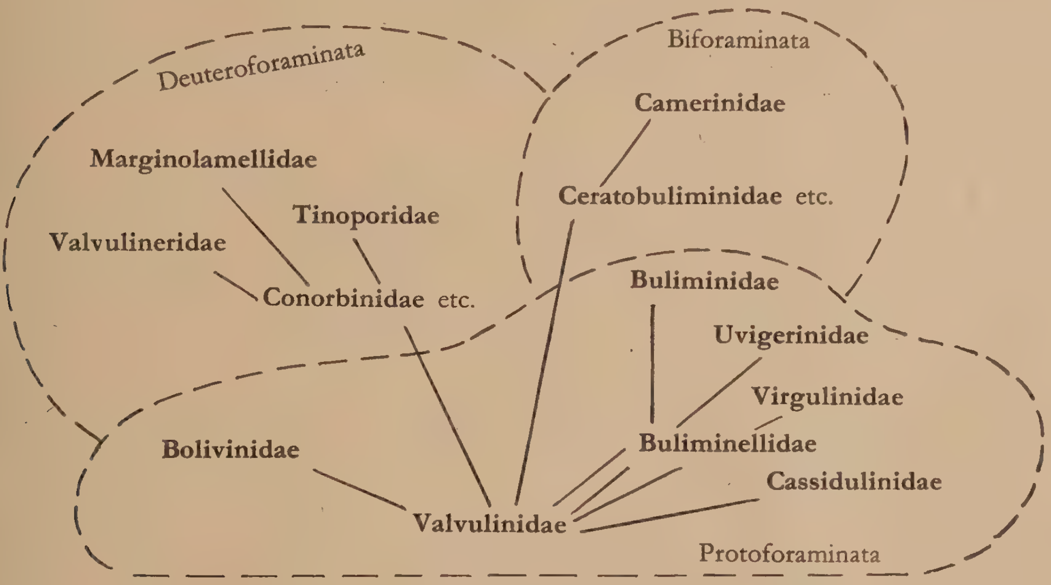
In many more developed species of a genus, mostly from later geologic date, often pores occur which are much larger in size than the protopores. They in most cases show to have developed from groups of pores, gathered into a single larger pore. They have been called deuteropores. In some cases parts of the toothplates have developed rounded openings, much resembling the deuteropores of the walls; these pores have been called toothplatepores. They often occur in those cases, in which parts of the apertural face have been formed by the toothplate.

The size of these different kinds of pores, and their arrangement over the test, are both of high systematic value, as they are less influenced by outer circumstances than the whole shape of the tests.

All these characteristics however cannot be studied in a dry state of the test. So, I always studied the tests in a clarifier, the most easily usable kind showing to be ricinic-oil. This oil penetrates the minor cavities in a short time, and moreover enclosed airbubbles dissolve into the oil in course of few days. The oil remains liquid during several years and outer details remain visible also.

Short characteristics of the families

Valvulinidae. In the earlier stage always triserial or polyserial in primitive forms, and in the microspheric forms even so in more developed forms. Many genera in later stages biserial or uniserial. In the typical forms the walls consisting of a large amount of chalk cement, in which sandgrains are incorporated; in many more advanced forms the cement is dominating and the sandgrains are often totally absent. In these forms the difference with real calcareous forms is found in the rough surface of the cemented walls. In many forms the walls are pierced by pores, which always show the type of protopores, though often they are rather coarse. In more primitive forms the aperture is provided with a toothplate, attached to the proximal border of the aperture, but the plate never reaches the next foramen. In many more advanced genera the aperture becomes cribrate or is represented by a very large opening. Jurassic-Recent.


Deuteroforaminata
Biforaminata
Camerinidae
Marginolamellidae
Ceratobuliminidae etc.
Tinoporidae
Valvulineridae
Buliminidae
Conorbinidae etc.
Uvigerinidae
Virgulinidae
Bolivinidae
Buliminellidae
Cassidulinidae
Valvulinidae
Protoforaminata

Relations between the families of the *Dentata*

Bolivinidae. Calcareous, perforate, in the proloculus always finely perforate. Even the oldest known species (Jurassic) show the biserial arrangement of the chambers from the beginning. Toothplate always attached to proximal border of aperture, then running along the basal chamberwall with an attached part toward the next aperture, and attached to its opposite border, the distal one, and possessing a more or less developed free folded part. Next toothplate making an angle of 180° with former one. Aperture on basal suture, but in forms tending to become uniserially situated often more or less terminal, as in similar forms in the *Valvulinidae.* Jurassic-Recent.

Conorbinidae. In primitive forms only a protoforamen, with pillar-shaped toothplate and only protopores. In more advanced forms a deuteroforamen is present too, and then the protoforamen may be reduced or even obliterated. In that case the toothplate is reduced and even absent. The more primitive forms possess protopores, but the more advanced forms may develop deuteropores. In the primitive genus *Conorbis* with only a protoforamen, the chambers are polyserially arranged, but in some advanced forms the series may be reduced even to a biserial arrangement. Often a lip is formed ventrally between the protoforamen and the deuteroforamen, and in many genera with reduced protoforamen the lip becomes dominant. In highly developed forms the protoforamen gives rise to an umbilical canalsystem, while in other forms the protoforamen is closed by a special porous plate, giving rise to supplementary chamberlets. Jurassic-Recent.

Valvulineridae. Primitive forms of this trochoid family always show protopores. Only deuteroforamen with largely developed lip present, deuteroforamen opening into umbilical cavity, but often closed in older chambers. The lip has become dominant. Higher advanced groups show deuteropores. Primitive forms show no pores on dorsal side, those with deuteropores are often poreless on ventral side. No toothplates. Cretaceous-Recent.

Tinoporidae. Proto- and deuteroforamen existing, both on either side of the chamber; in more primitive forms the lip forms a third foramen opening in the umbilical cavity (*Cymbaloporetta*) but in most forms the lip is closed or even absent. The two nearly equally developed apertures give rise to the development of layers of chambers in several directions, and very highly developed tests arise in that way. In the megalospheric forms the initial chambers often show the raspberry-type, but in the microspheric form the primitive conorbina arrangement exists. Deuteropores throughout. Cretaceous-Recent.

Marginolamellidae. Forms, closely allied to the higher specialised *Conorbinidae,* always showing a distinct poreless margin. Protopores throughout. It may be, that this group belongs not here, but is allied to the next group, the *Ceratobuliminidae.* Protoforamen lacking, toothplate lacking, deuteroforamen mostly with prominent lip, often opening into umbilical cavity, as is the case in the *Valvulineridae.* Lower-Cretaceous-Recent.

Ceratobuliminidae. As in the primitive *Conorbinidae,* the walls are mostly opaque and of a yellowish colour. This colour may be a relict of the chitinous lining, found in many *Valvulinidae.* Always very fine protopores. Toothplate nearly always present, in its best development with attached part and free folded part, as in the *Bolivinidae.* In the most primitive forms the aperture is a protoforamen (*Ceratobulimina, Lamarckina*) but in more advanced forms a deuteroforamen is also present (*Biforaminata*). The protoforamen is often marginally placed, and always stands in connection with the toothplate. In cases in which both kinds of foramina exist, the deuteroforamen forms the septal one. In some higher advanced forms the protoforamen is reduced, but often the toothplate in that case is existing as well. In some very specialised forms the toothplate is very complicated, and reaches in the genera *Robertinoides* and *Cushmanella* its highest development. Jurassic-Recent.

Camerinidae. Toothplate very highly developed, and forming the marginal chord canalsystem. Protoforamen is the opening of that canalsystem, always small. Always protopores, as in the *Ceratobuliminidae.* As in *Cushmanella* from the *Ceratobuliminidae,* the tests always planospirally coiled. Tertiary-Recent.

Buliminellidae. Tests trochoidally coiled, polyserially. Toothplate in more primitive forms simple, somewhat resembling that of the *Cassidulinidae,* with attached part highly developed, free folded part more or less reduced. In higher developed forms the toothplate forms also part of the apertural face, often with radially placed furrows in it. Protopores throughout. Spiral always with high spead. In some advanced forms the arrangement of chambers becomes biserial. Cretaceous-Recent.

Buliminidae. Triserially arranged trochoid tests, with loop-shaped apertures mostly sutural.

Toothplate with attached part and free folded part, making angle of 120° with former and next one. Some forms tend to become uniserial. In highly advanced forms the toothplate is complicated and forms at its attached part a tube, ending in a second foramen. Primitive forms with fine protopores, more recent forms often with somewhat coarser protopores. Cretaceous-Recent.

Uvigerinidae. Triserially arranged chambers, in some species becoming uniserial, but always showing an angle of toothplate of 120°. Aperture mostly on apertural neck, often with phialine lip. Toothplate often platelike or slightly reduced. Protopores, always very fine. Tertiary-Recent.

Virgulinidae. Walls always very thin and hyaline. Protopores. Toothplate often highly developed, often with ornamentation. Beginning of tests always more or less triserial, later on irregular or biserial. Aperture always loop-shaped, with largely developed toothplate. In some pelagic forms chambers overlapping and inflated, and then toothplate often pillarshaped with fan-shaped free folded part. Tertiary-Recent.

Cassidulinidae. In most forms arrangement of chambers biserial, but in more primitive forms beginning triserially. Tests always opaque, with protopores. In some genera the test is originally elongate, in other forms coiled up, in some forms secundarily elongate. In *Pleurostomella* the test tends to become uniserial, and the aperture areal. In most forms it is loop-shaped and sutural (latero-marginal). Cretaceous-Recent.

Family *Valvulinidae*

This family has been given an exhaustive treatise in Cushman's work "A Monograph of the Foraminiferal Family *Valvulinidae*", Cushman Laboratory for Foraminiferal Rechearch, Special Publication No. 8, 1937.

To this family Cushman brings the genera *Valvulina, Arenobulimina, Eggerella, Marssonella, Dorothia* as those genera, which showed to be the more ancestral forms, whereas *Cribrobulimina, Valvulammina, Clavulina, Gunteria, Dictyoconus, Coskinolina, Lituonella, Pernerina, Orbignyna, Ataxophragmina, Hagenowella, Liebusella, Tritaxilina, Listerella, Karreriella, Chrysalidina, Textulariella, Cuneolina, Pseudorbitolina, Dicyclina, Cubanina, Matanzia, Plectina, Goësella* and *Cribogoësella* form the more developed and specialised genera.

The main typical feature of the family is, that the aperture shows a more or less developed valvular lip, attached to the proximal border of the aperture. The walls are agglutinated, but in many genera this agglutination is developed in a more or less secundary way, the cementation forming the larger part of the wall.

I could state, that many forms, belonging to this family, show fine pores between the added sandgrains of the test.

I could state these typical protopores in the following species: *Listerella communis* (d'Orbigny) from Rimini and the Red Sea; *Listerella nodulosa* (Cushman) from the Caribbean; *Listerella minuta* nov. spec. from the Pacific; *Listerella primaeva* from the Pacific, and in several species of "*Gaudryina*". I never observed them in any species of *Spiroplectammina* and *Spiroplectinata.* In many so-called *Textularia* they are likewise lacking, but coarse pores have been observed in "*Textularia*" *stricta* from the Pacific and protopores are very clearly shown in "*Textularia*" *catenata* from Rimini and elsewhere. Such coarse protopores have been observed too in those species, gathered here in the family of the *Valvulinidae,* called hitherto *Bifarina mackinnoni* and *Pavonina.* The genus *Bolivi noides,* lacking any trace of a toothplate as the now mentioned two species, shows however fine protopores. It may be an offspring of those "*Gaudryinae*". It cannot belong to the group, in which the genus *Gümbelina* is placed,whatever name this group may have, as Cushman is believing, as the aperture of *Gümbelina* does not show any relation with that of *Bolivinoides.* As I have shown in this paper, the genus *Bolivinita* has to be dropped, as real *Bolivinita planata* and *eleyi* possess no pores at all, and may be allied to some poreless *Siphogaudryina,* whereas *Bolivinita quadrilatera* is a true *Bolivina* with a well-developed toothplate. Facts point to a relationship with those calcareous families, which likewise show a "lip" attached to the proximal border of the aperture, the toothplate-Foraminifera. So I believe, that the ancestral forms of the Toothplate-Foraminifera have to be sought for in the *Valvulinidae.* So I have gathered this family with those calcareous Foraminifera, which show a toothplate or have apparently derived from such forms, in a new order of Foraminifera, the Dentata or toothplate-Foraminifera.

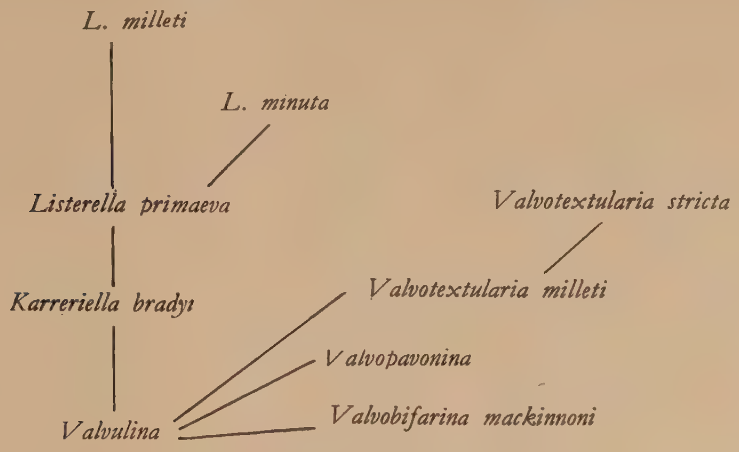
In many of the higher developed forms the agglutination of the test is obliterated, whereas the chitinous inner lining has developed into the real wall, now more or less porous. Some of these forms, hitherto described as belonging to quite different types, I have preliminarily placed in the family of the *Valvulinidae,* though it may be, that they are belonging to the *Verneuilinidae.* These forms are known as *Pavonina* and *Bifarina.* They show a very typical structure of the walls, never really polished outwardly, always rough, but totally consisting of chalk-material. Their pores are always rather coarse, but seem to belong to the protopores. As their mouthes are always open and lack any trace of a valve, they may not belong to the family at all, but to the *Verneuilinidae.* They always begin with a triserial stage, afterwards developing into biserial or even uniserial chambers, as in many *Valvulinidae.*

New is the discovery of real protopores in the walls of many species of this family. It may be, that all species will show these pores at closer examination.

This chapter deals only with the genera *Karreriella, Listerella, "Textularia", Pavonina* and *Bifarina.* In another paper I have dealt with *Hagenowella,* and in my work on the West-Indian Foraminifera I shall deal with some other genera too. Several species of so-called *Textularia,* always with pores between the sandgrains, but showing at least in the microspheric forms a tendency to remain triserially arranged in the initial part, have been found to belong in reality to the *Valvulinidae.* To these textularian tests belong *Textularia stricta* from the Pacific and *Siphotextularia catenata* from the West-Indian region.

Many species, hitherto known as *Textularia,* show fine protopores in their walls between the agglutination. Often they possess typical tubular apertures, as are found in *Listerella.* In some of them traces of a triserial arrangement of the initial chambers can be found, as in *"Textularia" milleti*; in all, at least in the initial parts, fine pores are found. I am convinced, that these species, many of which have been found in the West-Indian area, do not belong to the genus *Textularia,* but have to be placed among the *Valvulinidae.* So I will call them here *Valvotextularia.* This group shows, as is the case in *Pavonina* and in *"Bifarina" mackinnoni,* no trace of toothplates; yet the existence of protopores shows the relation with the *Valvulinidae,* and often the neck at the aperture once more points to that family. I thus called the genus *Pavonina*: *Valvopavonina,* whereas *"Bifarina" mackinnoni* has been called here *Valvobifarina,* as I showed elsewhere, that the genus *Bifarina* cannot be maintained.

The different species here studied may have been developed in the following manner:



Geographic distribution.

Karreriella bradyi: Western and eastern part, Atlantic, Mediterranean.
Listerella primaeva: western part only, Borneo.
Listerella minuta: western part, with a geographic variety in the eastern one.
Listerella milleti: western part, up to Macassar-strait.
Valvotextularia milleti: only western part.
Valvotextularia stricta: in the western part the variety *vertebralis,* in the eastern the variety *stricta.* They are geographic varieties.
Valvopavonina flabelliformis: western part.
Valvobifarina mackinnoni: western part only.

All species are known from the western part of the Archipelago, and only 3 of them occur in the eastern part too, two of which show geographic differences with the type.

Genus **Karreriella**

This genus has been founded for those *Valvulinidae,* beginning with an initial part arranged in whorls of 4 or 5 chambers. Yet I believe, that the erection of this genus was a premature one. For I found in some genera of the West-Indian area, that the microspheric form begins with the *Karreriella*-type, whereas the megalospheric form is not so arranged. Moreover, typical species of *Karreriella* showed to begin in all generations triserially. Yet I have maintained the genus as our knowledge about the different species of it is not yet detailed enough to solve this question. The genus has been described sufficiently by Cushman and others. In any case I made it clear, that the different species of it show a porous wall.

Karreriella bradyi Cushman

(Figs. 2-4)

The species occurred South of Sumatra in depths ranging from 330 to 613 fathoms, always rarely, and in some specimens at 9° 29′ S., 120° 19′ E., depth 330 fathoms.

Cushman in 1937 classed it with his new genus *Karreriella,* presuming that the first chambers were arranged in a coil of four or five chambers.

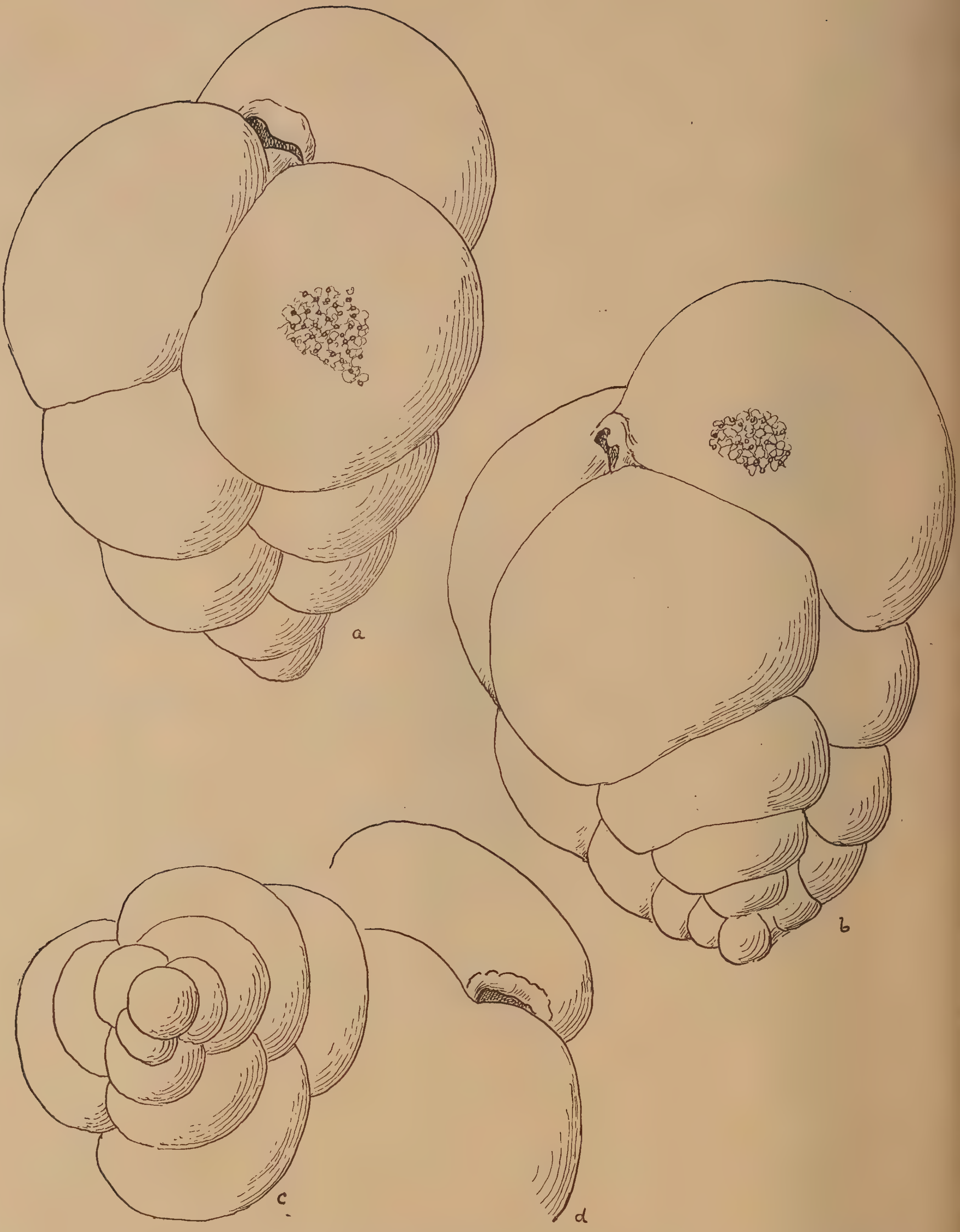


Fig. 2. *Karreriella bradyi.* a and b, two megalospheric specimens; c, initial part from below; d, aperture of a third specimen; × 432; in a and b part of surface with the protopores are drawn.

When one, however, grinds down an individual from the apertural end gradually towards the initial part, one comes to the conclusion, that both in microspheric and in megalospheric specimens

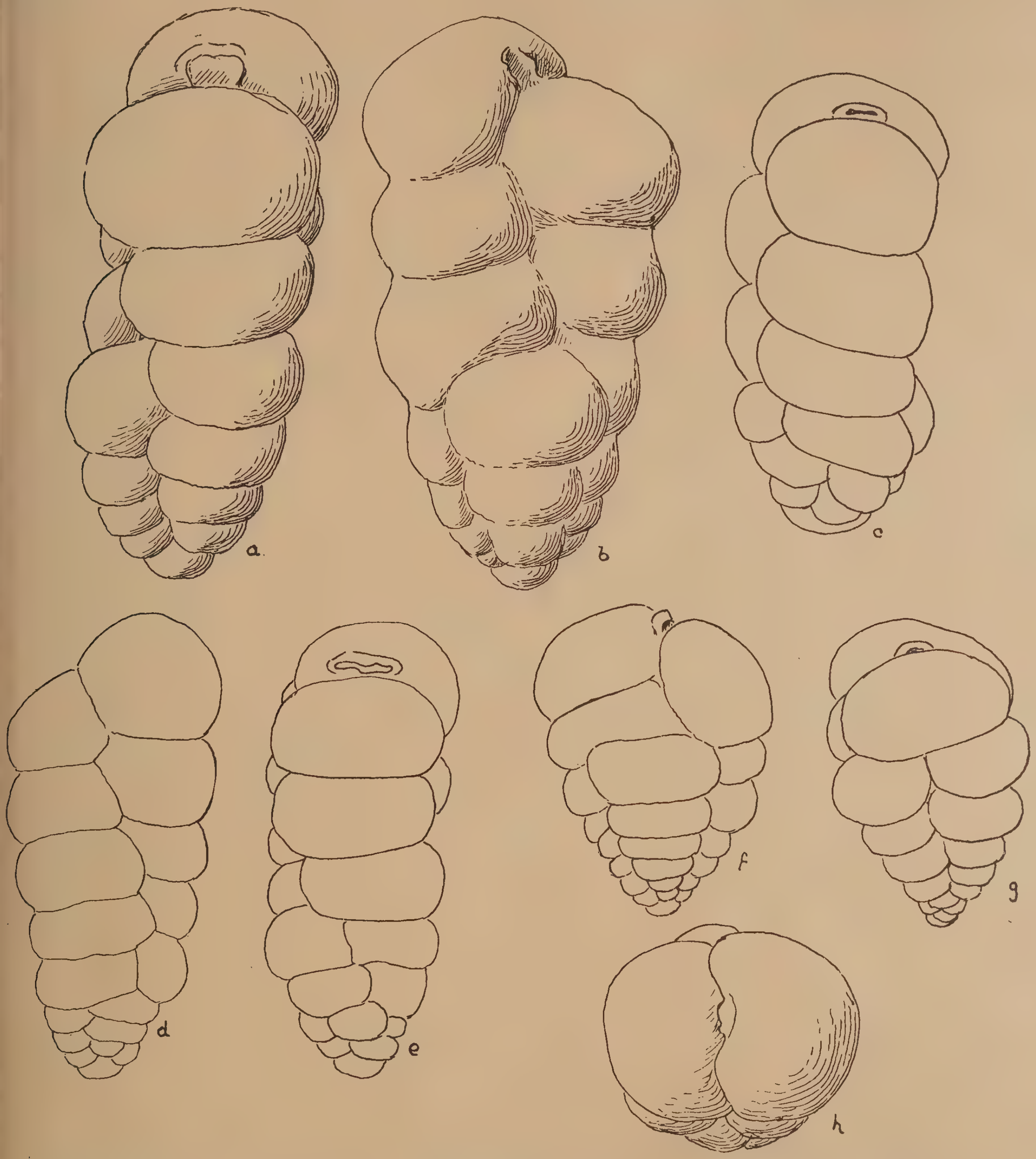


Fig. 3. *Karreriella bradyi.* a, b, outgrown megalospheric specimen, seen from two different sides; c, second specimen; d, e, another individual, seen from two sides; f, g, h, microspheric specimen, seen from three sides. All figures × 96.

the arrangement of the chambers is throughout triserially, and that the error is due to the overlapping of the later chambers, which, when seen from below, suggest a coil of more than three chambers in the beginning. All species of this group should be studied anew with this method. I found for instance, that the genus *Hagenowella,* also presumed to be coiled in the initial part, likewise is triserially arranged throughout, and that here too the presumed coiled arrangement of the first

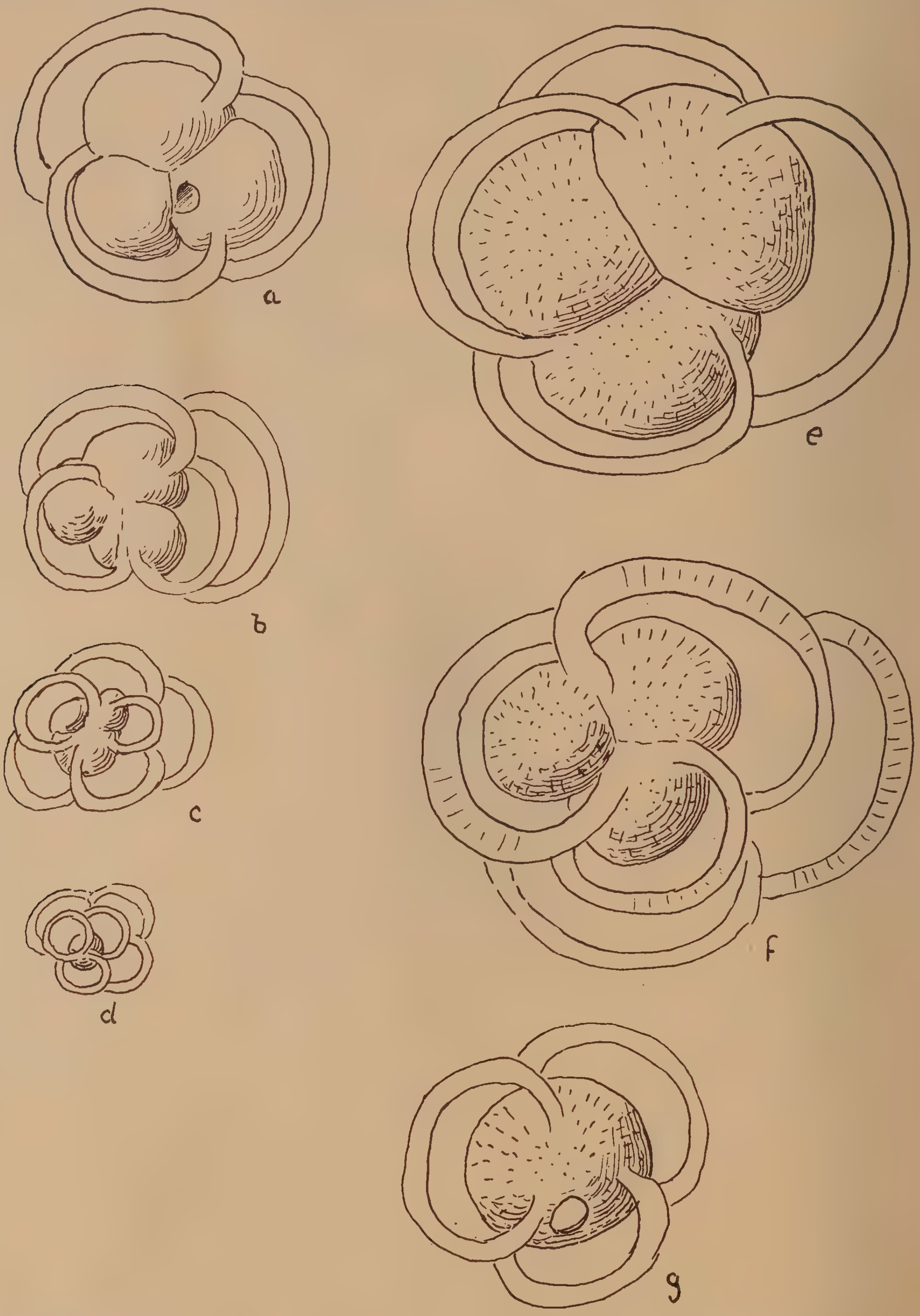


Fig. 4. *Karreriella bradyi.* a, b, c, d, four successive sections through initial part of microspheric specimen, showing the triserial arrangement of the chambers. As the chambers are overlapping, those of next whorl are sectioned too; e, f, g, successive sections through initial end of megalospheric specimen; showing triserial arrangement and fine pores; × 480.

chambers is erroneous, due to the overlapping of the later chambers, which, in this genus, moreover, are divided into chamberlets, which makes a study the more difficult. When one sections a specimen of the genera *Karreriella* or *Hagenowella,* beginning with the proloculus, one comes always to this erroneous conclusion, as one observes the overlapping chambers in the section together with the first chambers. When grinding down from the opposite direction, and studying the successive sections in drawings, however, the conclusion can be only, that the arrangement is triserial. *Karreriella bradyi* is characterised by its contorted series of biserial chambers, and the very smooth arenaceous walls with their light yellowish colour. The aperture forms a narrow slit, surrounded by a protruding lip, being interio-areal.

In the microspheric form 7 sets of triserial chambers follow the proloculus, which has a diameter of 10 μ. The biserial chambers are only represented by a single set of two chambers, at least in the individuals, found in the material described above. In the megalospheric form (the material was not large enough to analyse the two generations) only four sets of triserial chambers are formed, and then four or five sets of biserial chambers are added. These chambers are not arranged in a single plane, but the plane, in which they lie, gradually changes, always in the same direction. The first chambers show protopores; they are also found in all later chambers; this fact, together with the valve over the aperture and the slightly protruding aperture shows, that though the species is triserially arranged troughout in the first part, it belongs in the family of the *Valvulinidae.* Yet, when one does not consider pores and the shape of the aperture, one would be inclined to call it a *Gaudryina.* Though it seems to me, that the genus *Karreriella* has no real value in systematic respect, I have provisionally maintained this name. I shall give more detailed thoughts on this name in my work on the West-Indian Foraminifera.

Genus **Listerella**

In this genus are gathered all those typical *Valvulinidae,* beginning polyserially, while afterwards a biserial arrangement is followed by an uniserial one. In *Valvulina* and *Karreriella* the toothplate over the aperture is the normal one, attached to the proximal border of it. But in the uniserial parts of its members the toothplate is closing in the whole terminal aperture, forming a more or less developed neck. This characteristic reminds in many ways the toothplate of the uniserial forms of *Bolivina,* in which likewise the plate has become free from the wall. All species of *Listerella* observed showed to possess protopores in the walls.

Listerella primaeva (Cushman)

(Fig. 5)

This species occurred in several specimens at St. 1° 51′ S., 99° 36′ E., depth 683 fathoms and 2° 26′ S., 99° 35′ E., depth 582 fathoms. It hase been fully and accurately described by Cushman (Lab. For. Res., special publ. No. 8, 1937, p. 153, pl. 17, fig. 24-28). This description runs:

"Test elongate, slender, cylindrical, early portion slightly expanded, later uniserial portion much elongate, rounded in transverse section, early whorl with four or five chambers, later triserial and usually with a long biserial stage before the final chambers are developed; chambers distinct, very slightly inflated, slightly overlapping; sutures distinct, slightly depressed; wall thick, finely arenaceous, smoothly finished; aperture elongate; terminal, with a slight neck. Length up to 3 mm; diameter 0,25 mm."

Cushman mentions it from Sibuko Bay, Borneo, widely distributed in the Philippines. It is now found too in the Mentawei Basin, south of Sumatra, and so it shows to have a wide distribution among the Indo-Pacific Isles.

When observing the walls with high magnification, fine pores are found between the fine agglutination of the walls. These pores are of the normal shape and size, found in many of the *Valvulinidae.* As Cushman has pointed out already, the variation in the arrangement of the chambers is a large one. In some specimens the biserial stage is almost wanting, whereas in other specimens the uniserial part is very short and the biserial one formed by many chambers. It shows to be a primitive form among its genus, and the development of the various series of chambers seems

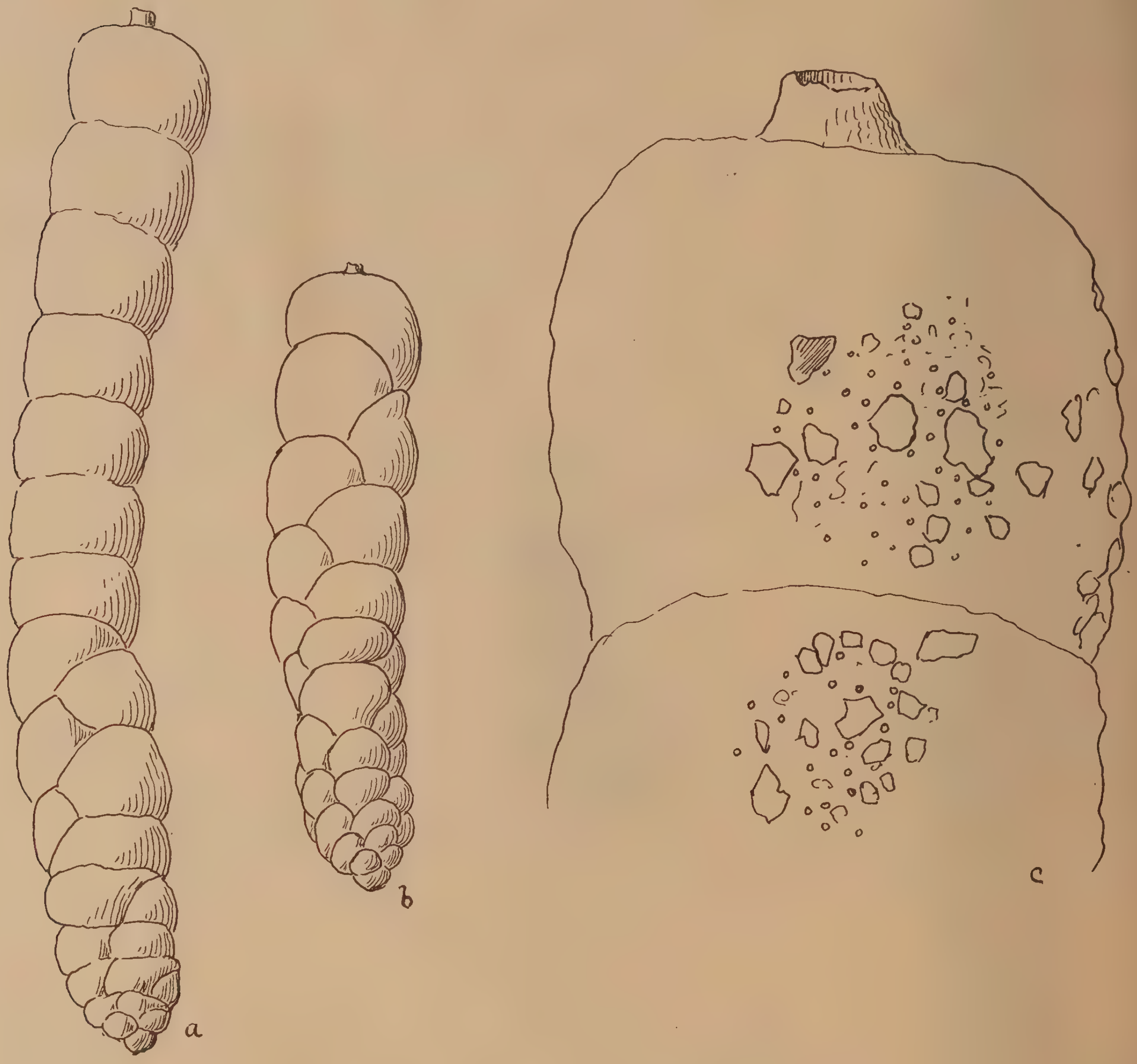


Fig. 5. *Listerella primaeva.* a, b, two specimens with different development of biserial and uniserial chambers, × 80; c, enlarged apertural end, showing surface with protopores between the agglutination, × 480.

to be induced by the size of the proloculus. The material however was not large enough to state this statistically.

Listerella minuta nov. spec.

(Fig. 6)

This small species was found in several specimens at St. 1° 35′ S., 99° 52′ E., depth 977 fathoms and 1° 51′ S., 99° 36′ E., depth 683 fathoms; 9° 10′ S., 120° 10′ E., depth 490 fathoms; 2° 17′ S., 99° 56′ E., depth 613 fathoms. The specimens show but little variation and can be described as follows:

Test elongate, small, length up to 1,5 mm, diameter up to 0,2 mm. Initial part only slightly thicker than the uniserial one; it consists of two sets of quadri-or triserial chambers, and a single set of biserial ones. Then 6-12 chambers of the uniserial arrangement are added. These chambers are much inflated, and show consequently much depressed sutures. As they overlap, only the last-formed chamber is rounded, the former chambers half as long as broad. Surface roughly finished, but with fine agglutination, between which the fine pores can be seen easily. Aperture terminal, rounded, with a distinct neck.

The species seems to be most allied to *L. antillarum.* Especially those specimens, found at St. 9° 10′ S., 120° 10′ E., showed a rather rough surface, with sharply pointed particles all over protruding from the surface.

Only megalospheric specimens were met with. They showed to begin with a proloculus with a diameter of about 30 μ, followed directly by a set of four chambers, from which however one is placed somewhat higher than the other three; this set is followed by a second one, similarly placed. Then follows a set of three chambers, and then a set of two chambers is added. After this single set of two chambers the uniserial chambers are added. All quadri-serial, triserial and biserial chambers have obliquely placed round apertures with a short neck, thus indicating the relation of *Listerella* to those species, in which a neck is found at the aperture (*Siphotextularia catenata* f.i.). May be, that the species is identical with what has been called by Brady, *Clavulina parisiensis* d'Orbigny (Challenger Report Pl. 48, fig. 15). The dimensions agree fully. As to Cushman, however, the species is not identical with *Clavulina parisiensis,* and the aperture of our species is that of *Listerella* and not of *Clavulina.*

Listerella milleti Cushman

(Fig. 7)

This species has been described by Cushman (Lab. For. Res., special publ. No. 8, 1937, p. 153, pl. 17, fig. 20) as follows:

"Test large, elongate, slender, early bulbous portion small compared with the size of the test, circular in transverse section; chambers distinct, later ones becoming somewhat inflated, slightly overlapping, increasing gradually in height toward the apertural end; sutures distinct, becoming somewhat more strongly depressed toward the apertural end; wall coarsely arenaceous, somewhat roughly finished; aperture terminal, rounded, with a distinct neck. Length up to 4 mm; diameter 0,60—0.65 mm."

There has been mentioned by Cushman only a single station, in which the species was

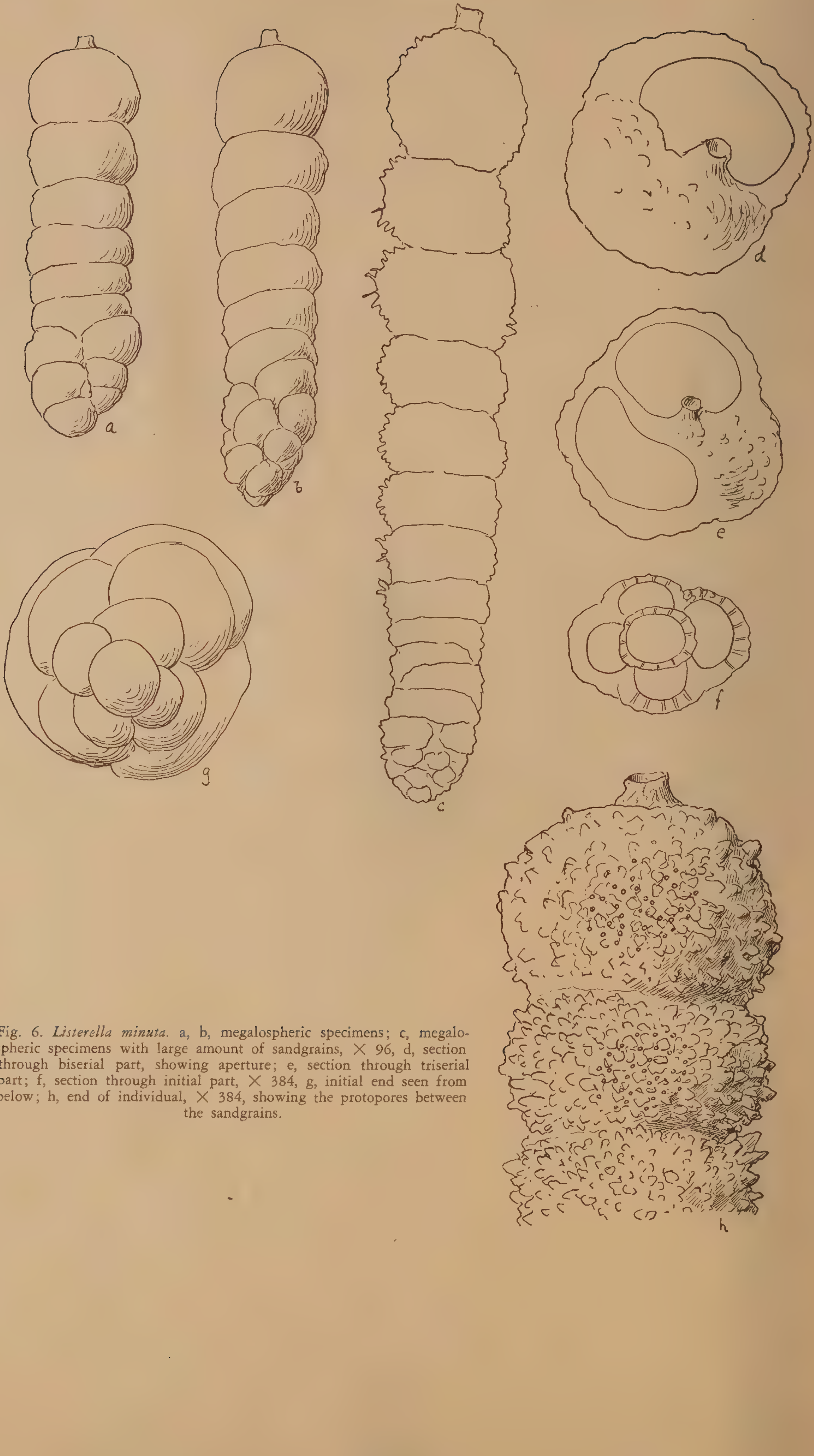


Fig. 6. *Listerella minuta.* a, b, megalospheric specimens; c, megalospheric specimens with large amount of sandgrains, × 96, d, section through biserial part, showing aperture; e, section through triserial part; f, section through initial part, × 384, g, initial end seen from below; h, end of individual, × 384, showing the protopores between the sandgrains.

common, Macassar Strait in 1181 fathoms depth. I found it in several specimens, all being young ones, at St. 2° 58′ S., 99° 47′ E., depth 928 fathoms, bottom temperature, 3,8° C. and 9° 29′ S., 120° 19′ E., 330 m., 9° 20′ S., 120° 16′ E., 285 fathoms. So it seems to be a deep-water form. The texture of the walls shows, that most of the material used is a fine detritus, thickly cemented, and that between those particles of detritus fine pores can be seen, as usual in all species of *Listerella.*

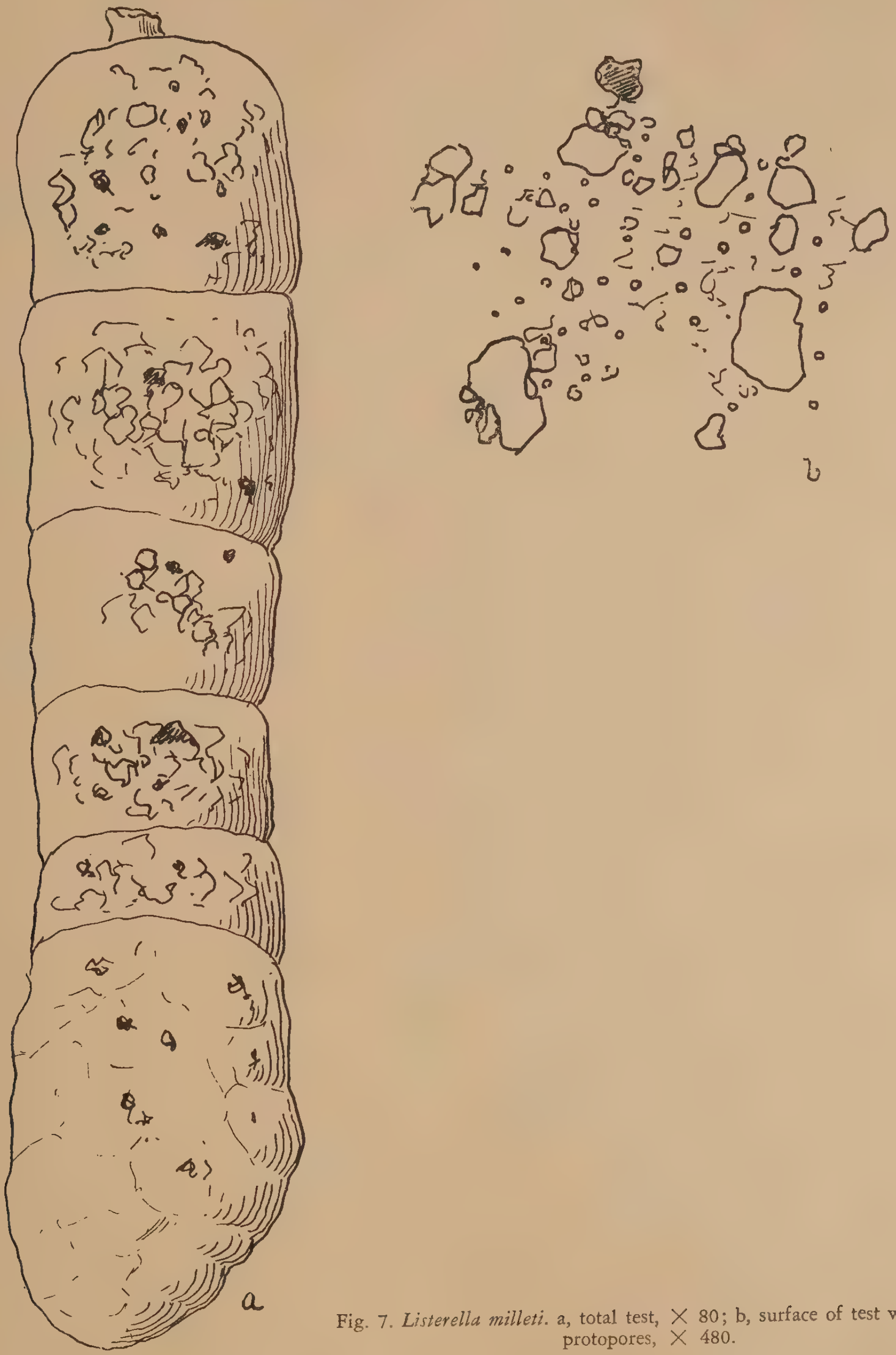


Fig. 7. *Listerella milleti.* a, total test, × 80; b, surface of test with the protopores, × 480.

Genus **Valvotextularia**

Many forms, hitherto known as *Textularia,* show protopores in the walls. This characteristic, common and typical for the *Valvulinidae,* points to that family. Moreover all those species show a very fine agglutination and apertures which in several species are not of the typical simple type of *Textularia,* but show a more or less developed valvular plate or a short neck, surrounding the aperture. This characteristic points once more to the *Valvulinidae.* So I have gathered all these textularian species into a new genus, *Valvotextularia.* They are *Valvulinidae,* in which the initial part only in some cases shows a relict of the polyserial arrangement, but several other characteristics strongly indicate the *Valvulinidae.*

The genotype is *Valvotextularia catenata* (Cushman) from the West-Indian area.

Valvotextularia milleti (Cushman)

(Figs. 8-10)

This species, known as *Textularia milleti* Cushman and *Spiroplectammina milleti* (Cushman) has been found in several gatherings south of Sumatra viz. 2° S. 100° E., 222 fathoms, 2° S.,

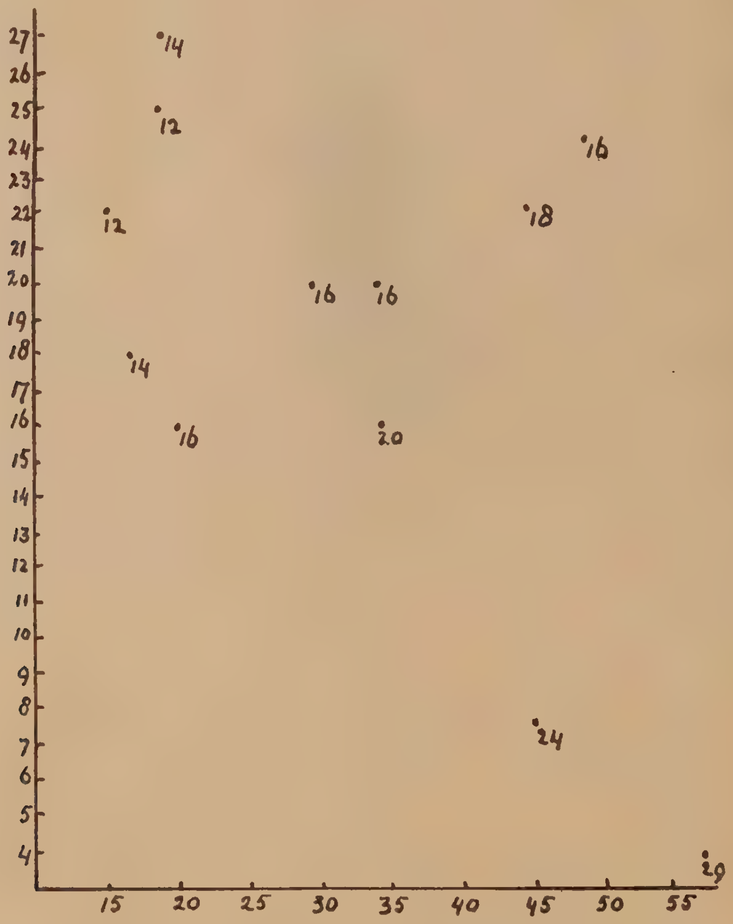


Fig. 8. *Valvotextularia milleti.* Diagram, showing relation between the product of length and breadth (horizontal) and the size of the proloculus (vertically). Figures added show the number of chambers. The main group ranging from 15 to 27, may be the A2-form, the single specimen at 8 may be A1, whereas that at 4 is a B-specimen. The measures of size of proloculus are in mm, × 480, those in horizontal line in cm × 80.

99° E., 377 fathoms, 2° S. 99° E., 405 and 613 fathoms (here abundant) and at 1° S., 99° E., 683 fathoms.

Closer examination of this very typical species showed, that Cushman's description (U.S. Nat. Mus., Bull. 161, 1932, p. 7) does not altogether agree with the specimens, found here, though I am convinced, that it is the same species. My description, or the altered description by Cushman, runs as follows:

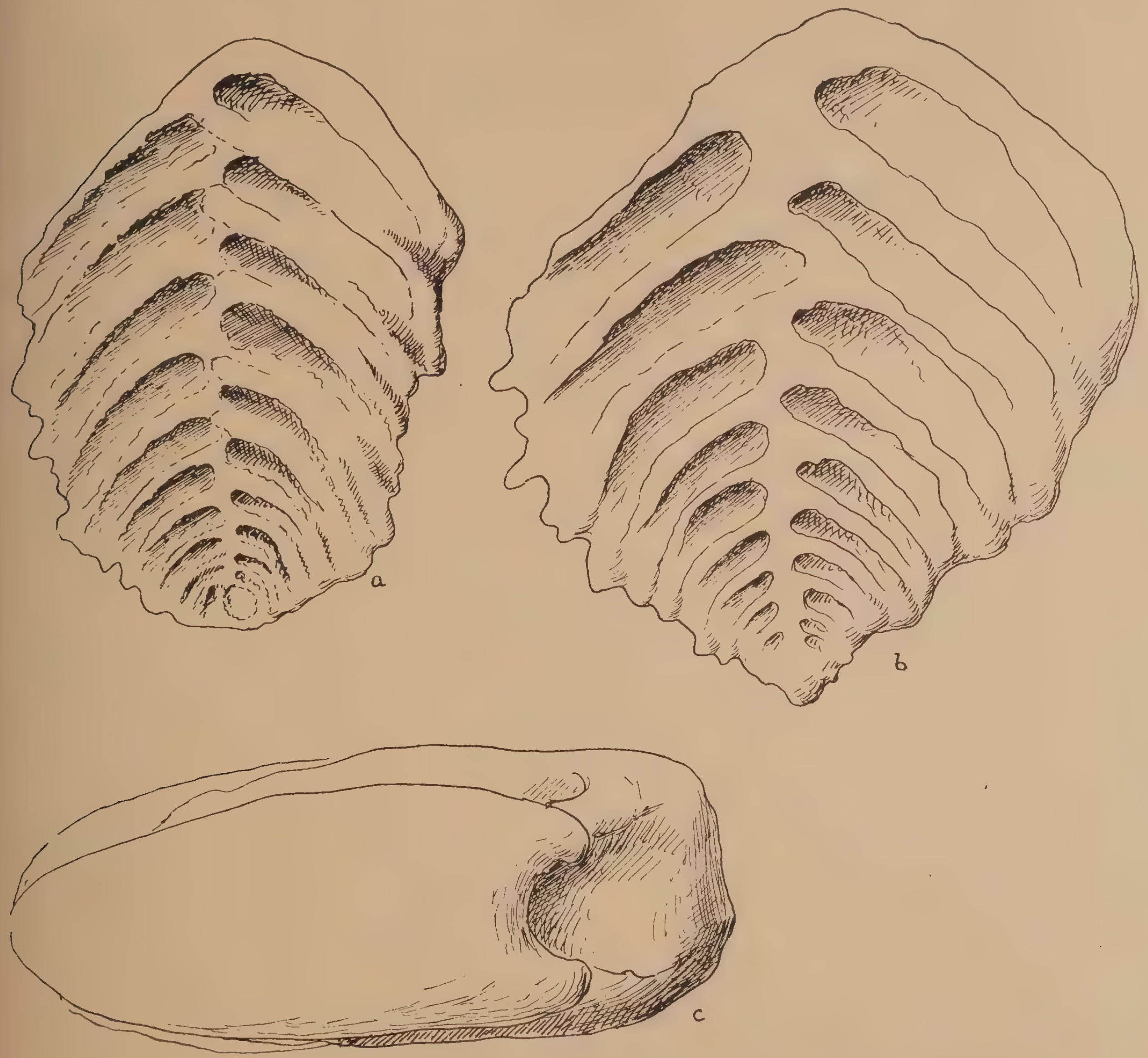


Fig. 9. *Valvotextularia milleti.* a, megalospheric; b, microspheric individuals; c, apertural face, × 95.

Test compressed, in some tests as long as broad, in others, especially in the A_2-generation, up to 1½ × as long as broad, composed of 14 to 29 broad, low chambers, the whole test rapidly increasing in width, and especially in A_1- or B-specimens, in the same way in thickness. Periphery rounded to acute, often with two rounded ridges. Each chamber with the initial suture thickened, which thickening is irregular, so that it looks like coarsely arenaceous. But in reality the walls and

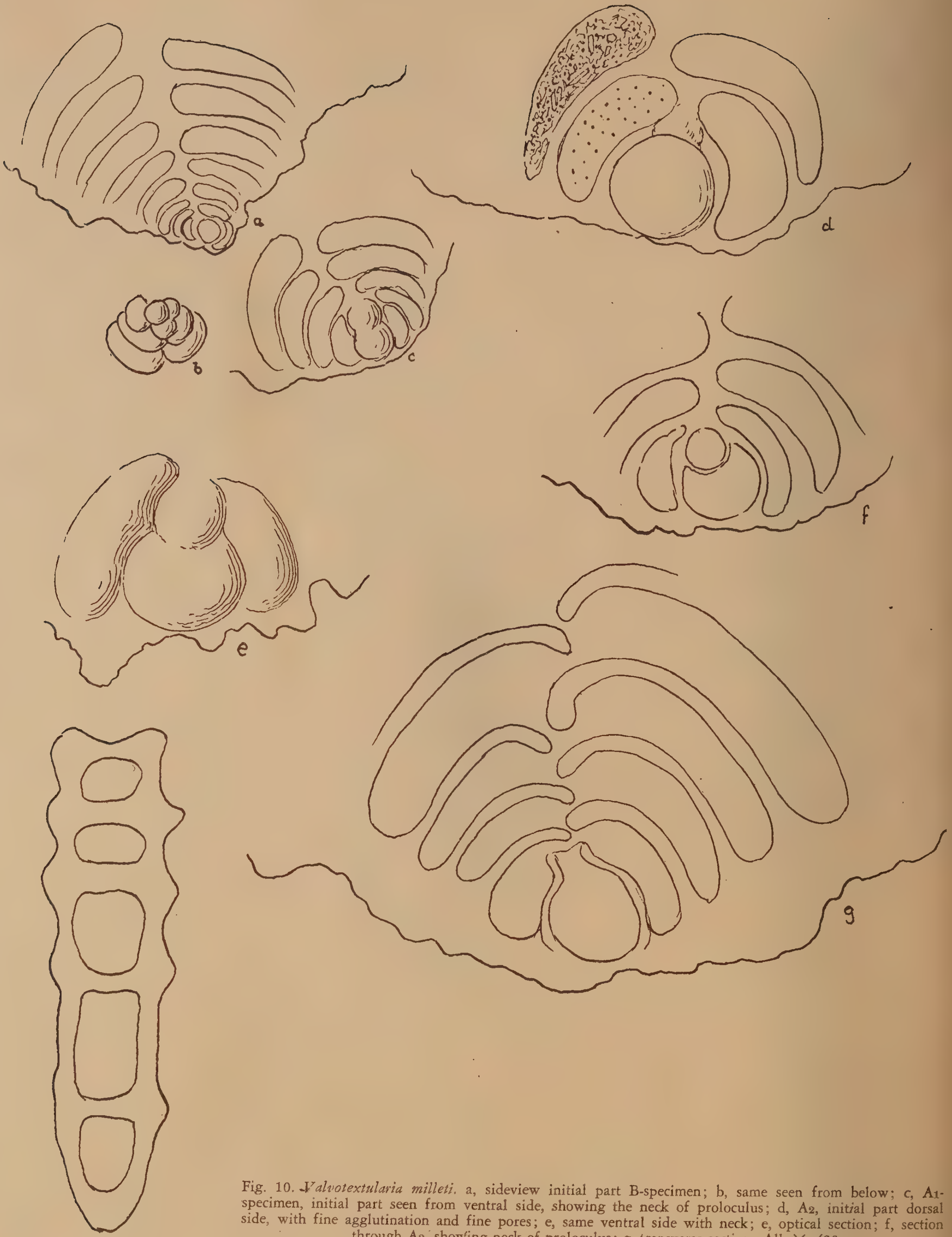


Fig. 10. *Valvotextularia milleti.* a, sideview initial part B-specimen; b, same seen from below; c, A_1-specimen, initial part seen from ventral side, showing the neck of proloculus; d, A_2, initial part dorsal side, with fine agglutination and fine pores; e, same ventral side with neck; e, optical section; f, section through A_2, showing neck of proloculus; g, transverse section. All × 420.

the thickening are built up with the aid of very fine material, mainly fine sandgrains, parts of diatoms and sponge-spicules. Between these agglutinations very fine, if at all visible, protopores are found. The oral part of each chamber is somewhat concave and smooth, so that the surface of the test is composed of an alternating series of raised, rough ridges and smoother depressions. Wall very finely arenaceous. Aperture narrow at the suture of the lastformed chamber, sunken down between two inflated sides, without any lip.

In the A_1-form, with proloculus of about 8-14 μ, the proloculus is followed by a sort of second chamber of about the same diameter, which chamber is situated toward the apertural end of the test. This second chamber opens in the proloculus by a rather wide opening, thus being possibly nothing else as a neck-chamber. Then a third chamber is added, which surrounds one side of the two-chambered portion, and this chamber shows to be the first of the biserial set of chambers, as it opens toward the middle axis of the test by a sutural aperture into the fourth chamber, surrounding the other side of the two-chambered protoconch. Then the normal textularian arrangement begins, the chambers rapidly becoming broader and somewhat more flattened. The initial part, seen from below, suggests strongly a triserial beginning.

In the A_2-generation, the proloculus has a diameter of 33 to 36 μ, measured transversely to the axis of the shell. This proloculus always shows a smaller second part, which may be seen at one of the sides of the shell, but not on the other side. This part, which is somewhat rounded too, opens into the first biserial chamber and has a wide opening toward the proloculus. In the A_1 (of B-) form this second chamberlet is also found only at one side of the test. Sections show, that it is a kind of neckchamber.

So the prolocular conditions are not identical with those of *Spiroplectammina,* neither recent nor fossil, while they do not agree with those of real *Textularia.* Thus I am obliged to create a new genus for similar species, which I will call *Valvotextularia.* To this group without doubt belongs *„Textularia" stricta,* as it shows the same agglutination, the pores and the inflated proximal chamber-parts. There are several other species, especially in the West-Indian region, with pores in the walls, which I intend to include in this new genus *Valvotextularia.* The genus seems to have derived from some *Karreriella,* reducing its initial polyserial part. It has nothing whatever to do with those Textularians which are obviously offsprings of *Spiroplectammina*; in the latter genus the beginning of the test is coiled in the same plan as the biserial part, and pores have not been observed in the walls.

Valvotextularia stricta Cushman

(Fig. 11)

The species was found in many specimens, most megalospheric, but some of them being microspheric, at St. 2° 26′ S., 100° 0′ E., depth 222 fathoms, and 2° 56′ S., 99° 58′ E., depth 405 fathoms. It showed, however, all outer characteristics of *T. vertebralis* Cushman. The structure of the test, however, was that described by me for *T. stricta* from the Key-Archipelago, with its very typical pores in the wall and its chitinous layer of dark brown material in the earlier chambers. Thus, there is no doubt whatever, that *T. vertebralis* and *T. stricta* are only varieties, bound to circumstantial peculiarities. Typical *T. stricta,* without the somewhat protruding buds on the chambers, which lead to *T. vertebralis,* were found at a depth of 290 m at the Key-Archipelago, and at 300 m and 120 m. The specimens, found south of Sumatra, showing the *vertebralis*-type, were both micro- and megalospheric, so the variation cannot be due to polymorphism. The depth here was 222 fathoms, thus about 400 m. Cushman mentions both forms from the Philippines, depth of

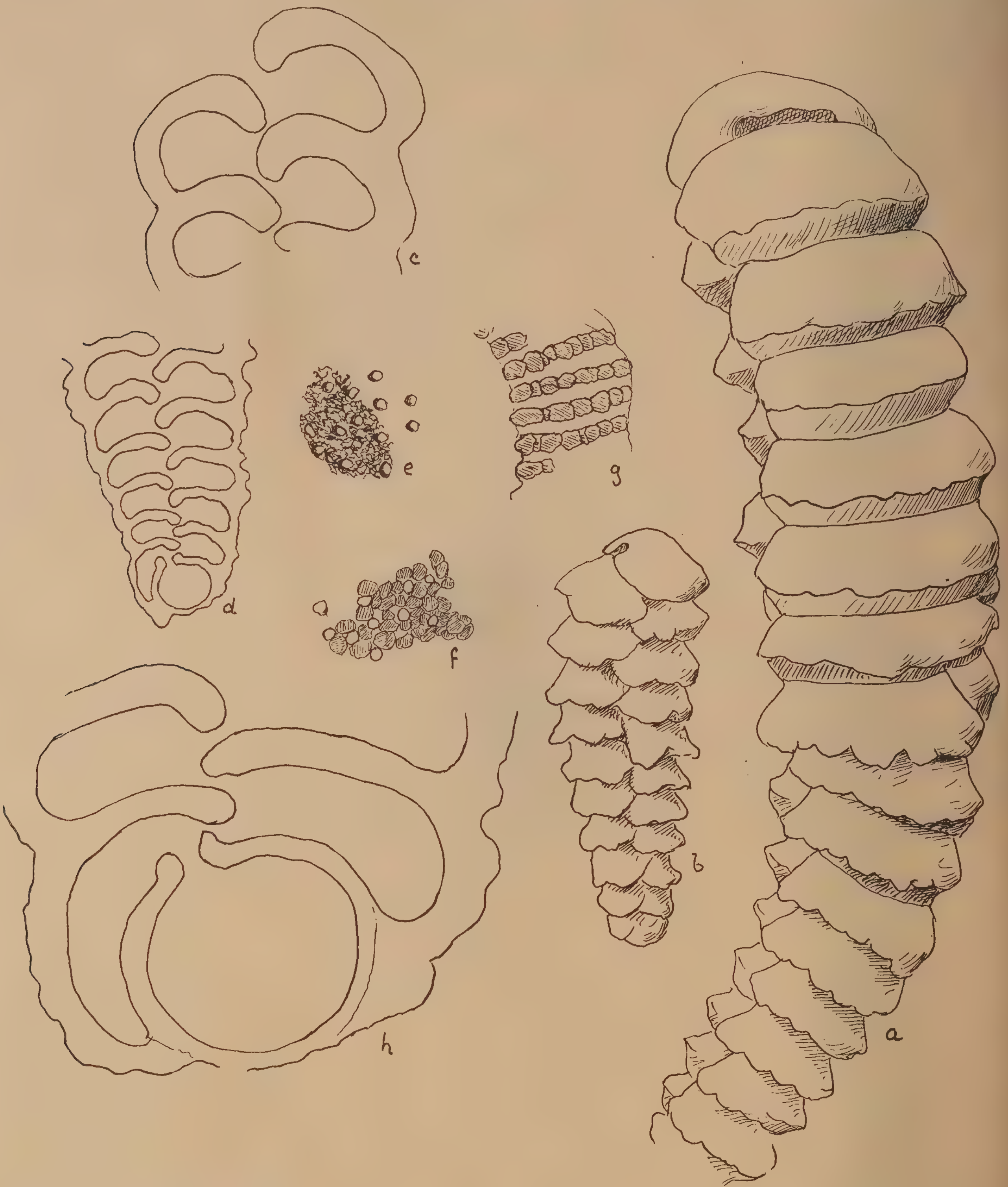


Fig. 11. *Valvotextularia stricta* (*vertebralis*). a, microspheric; b, megalospheric specimens, × 35; c, end of test, section; d, initial part of megalospheric form, section, both × 70; e, surface with the pores; d, section of wall parallely to surface, with pores; g, transverse section of wall, × 420; h, initial part of megalospheric specimen, × 420.

vertebralis ranging from 80 to 445 fathoms, while he gives a somewhat same depth for *stricta.* So the depth cannot be looked at as the factor, causing the difference in shape. As for the localities, given by Cushman for the two species, they seem to be about the same area. They all are typically tropical, and so are mine. The range of spreading for both species, considered as a single one, is from 21° N. to 5° S., and from 100° E. to 132° E.

Genus **Valvopavonina**

The genus *Pavonina* shows in some fossil species, according to Cushman, a more or less coiled arrangement of the initial part, but coiled in the plane of the later chambers. His coiling points to *Spiroplectammina.* But the recent species always show a triserial arrangement of the first chambers, followed by a biserial and uniserial arrangement. This fact points more to *Listerella.* Moreover the texture of the walls is that of an agglutinated test, though no sandgrains are incorporated. The possession of pores once more points to the *Valvulinidae.* So I shall distinguish these recent forms from those, described from the Tertiary, in establishing a new genus, *Valvopavonina.*

The genotype is *Pavonina flabelliformis* (d'Orbigny).

Valvopavonina flabelliformis (d'Orbigny)

(Figs. 12-15)

This species was found in about 7 specimens at St. 1° 51′ S., 99° 36′ E., depth 683 fathoms, and in a single specimen at Merak-anchorage, depth about 10 m.

Cushman described this species (Proc. U.S. Nat. Mus., No. 2597, 1926, p. 20) as follows:

"Test free, many-chambered, much compressed, the early portion consisting of a few small chambers arranged biserially, the later chambers curved, spreading uniserial or divided into more than one in each curve, in adults often with the chambers becoming almost annular; sutures somewhat limbate, depressed, distinct; wall thin and transparent, coarsely and irregularly punctate, the wall about those punctae often thickened and slightly raised; apertures in one or more linear rows about the periphery of the test, the peripheral face concave; colour white. The diameter of the test rarely exceeds 1 mm."

I can agree with the description but for the first sets of chambers. For sections showed very clearly, that the proloculus, which in all my specimens was megalospheric (diameter about 30 μ), was followed by three chambers situated nearly in a single horizontal plane, and then the biserial chambers were added, 3-4 pairs of them. Fullgrown specimens showed the typical surrounding with a raised border on the surface. They are mostly situated in a row near the upper suture of each chamber. The pores are coarse, and pierce through the very thick sidewalls of the chambers, often with a raised border on the surface. They are mostly situated in a row near the upper suture of each chamber, only few of them are scattered over the surface. Only in the last-formed chambers they may be found covering the whole surface of the chamberwall. The apertural face is provided with a single row of irregularly formed openings. The rounded foramen of the tri- and biserial chambers is situated on the ventral suture of these chambers. The initial part of the shells is often covered by irregular ridges and aisles of very clear shell-material. The proloculus shows some coarse pores only at one of its sides, while on the other very fine pores may be observed. A transverse section shows the very thick walls on the sides, whereas the apertural walls are always thin. The chambers of the later portion show thinner walls and are narrower than those in the middle of the test.

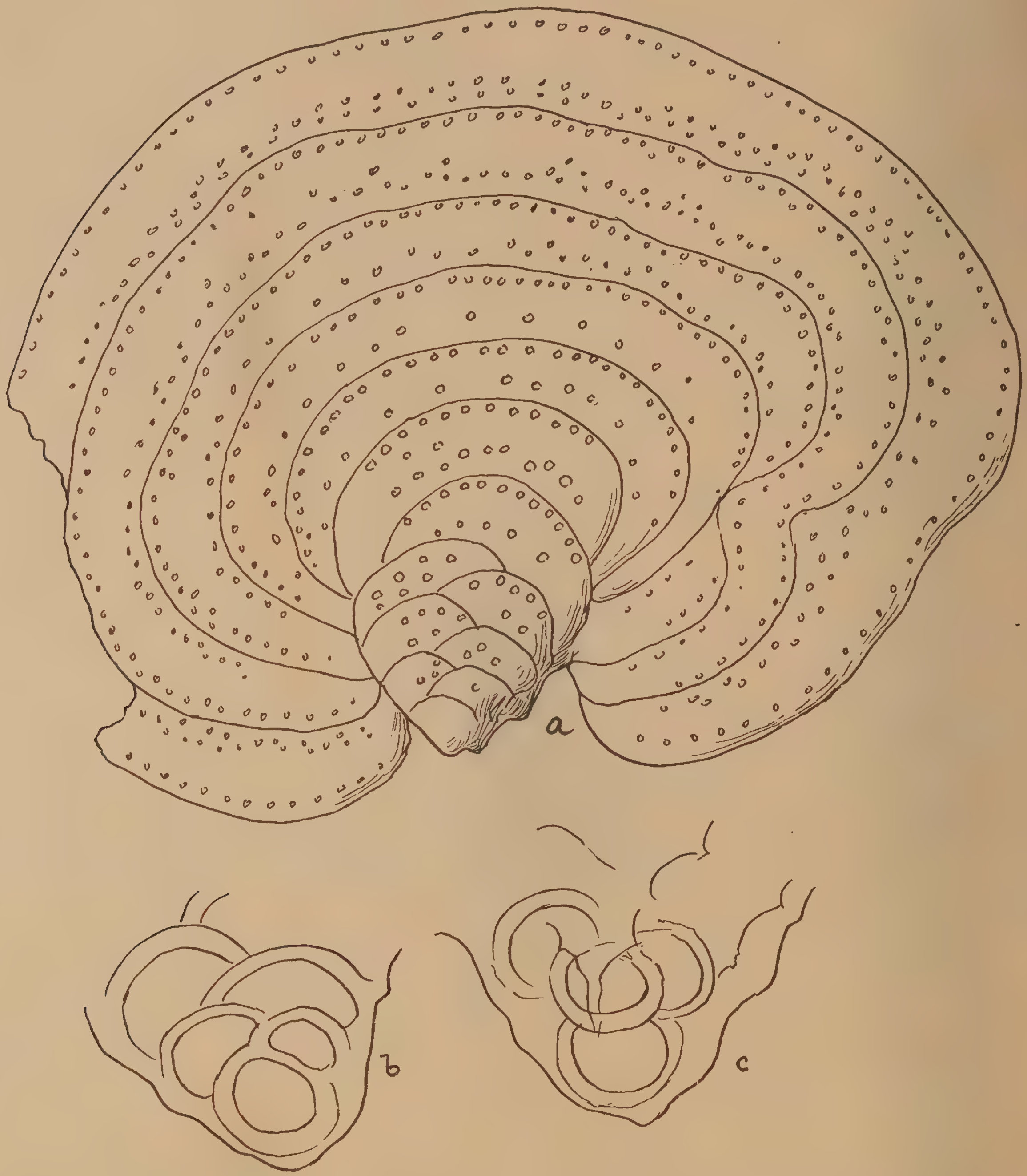


Fig. 12. *Valvopavonina flabelliformis.* a, Fullgrown specimen, convex side; b, concave side, initial part; c, convex side, initial part; the triserial arrangement of the chambers clearly shown; × 120; b, c, × 480.

The thick walls with the coarse pores, the initial part with the first chambers arranged triserially, the lack moreover of any trace of a toothplate indicate, that the species does not belong to the *Bolivinidae* or allied groups. The arrangement of the first chambers indicates a closer relation with genera like *Gaudryina*; Cushman mentions in the paper cited above some forms with arenaceous walls, viz. *Pavonina mexicana,* which phenomenon also points to *Gaudryina.* In many species allied to *Valvulinidae* I could trace coarse pores between the sandgrains of the agglutination; thus pores are not at all uncommon in this group. So I believe, that all those species, with clear chalk testwalls, and more or less porous walls, but with the early chambers, at least in the microspheric generations, triserially arranged, the later ones biserial, and with the chamberends directed towards the inital part (a feature, typical for the whole group) are closely allied to *Gaudryina* (*Siphogaudryina*) or some Valvulinid genus. Such genera are those, hitherto known as *Bolivinita* (except *Bolivinita quadrilatera,* which shows with its toothplate to be a real *Bolivina*), *"Bifarina" mackinnoni* and *Pavonina.* They do not belong to those genera with very fine pores, as *Plectofrondicularia, Amphimorphina,* etc., which form the main group of the *Heterohelicidae* of Cushman.

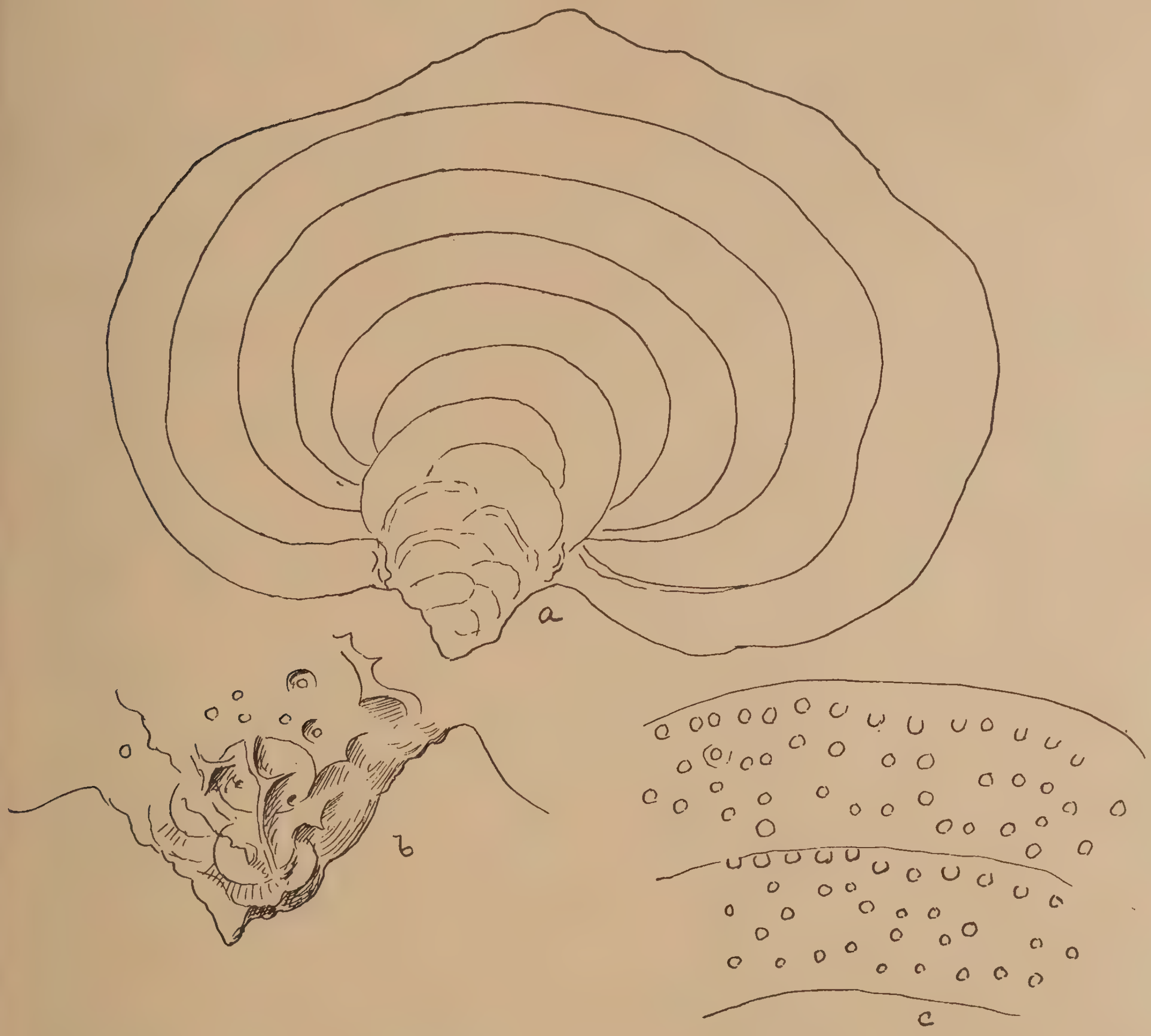


Fig. 13. *Valvopavonina flabelliformis*; a, fullgrown specimen; b, initial part, dorsal (convex) side; c, last formed chambers; pores; a × 108; b, c, × 432.

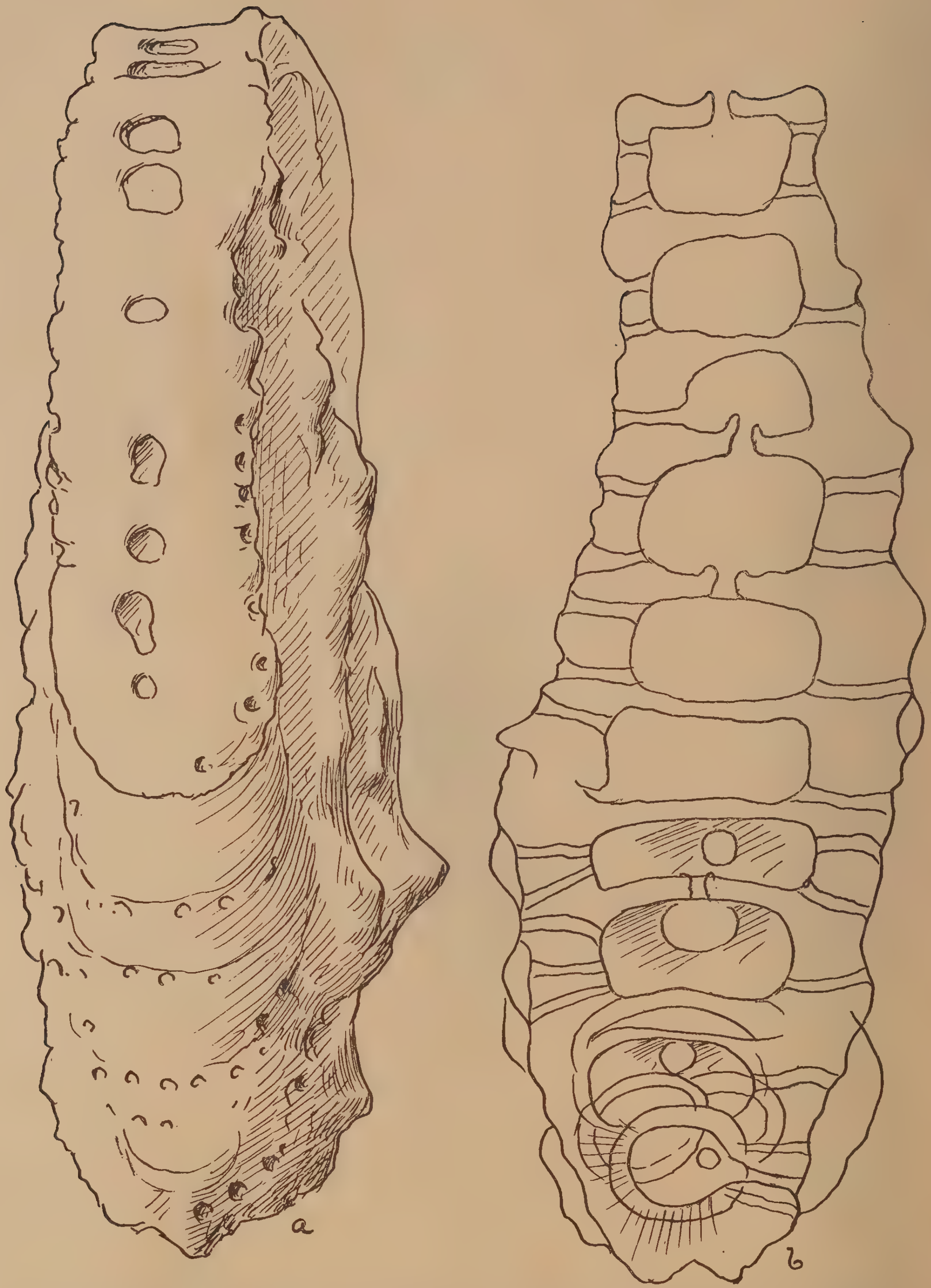


Fig. 14. *Valvopavonina flabelliformis.* a, whole specimen, from aside, showing apertural openings; b, section through the same specimen, showing septal foramina in uniserial and biserial chambers, coarse pores at both sides of the chamber but fine pores at only one side of proloculus. × 480.

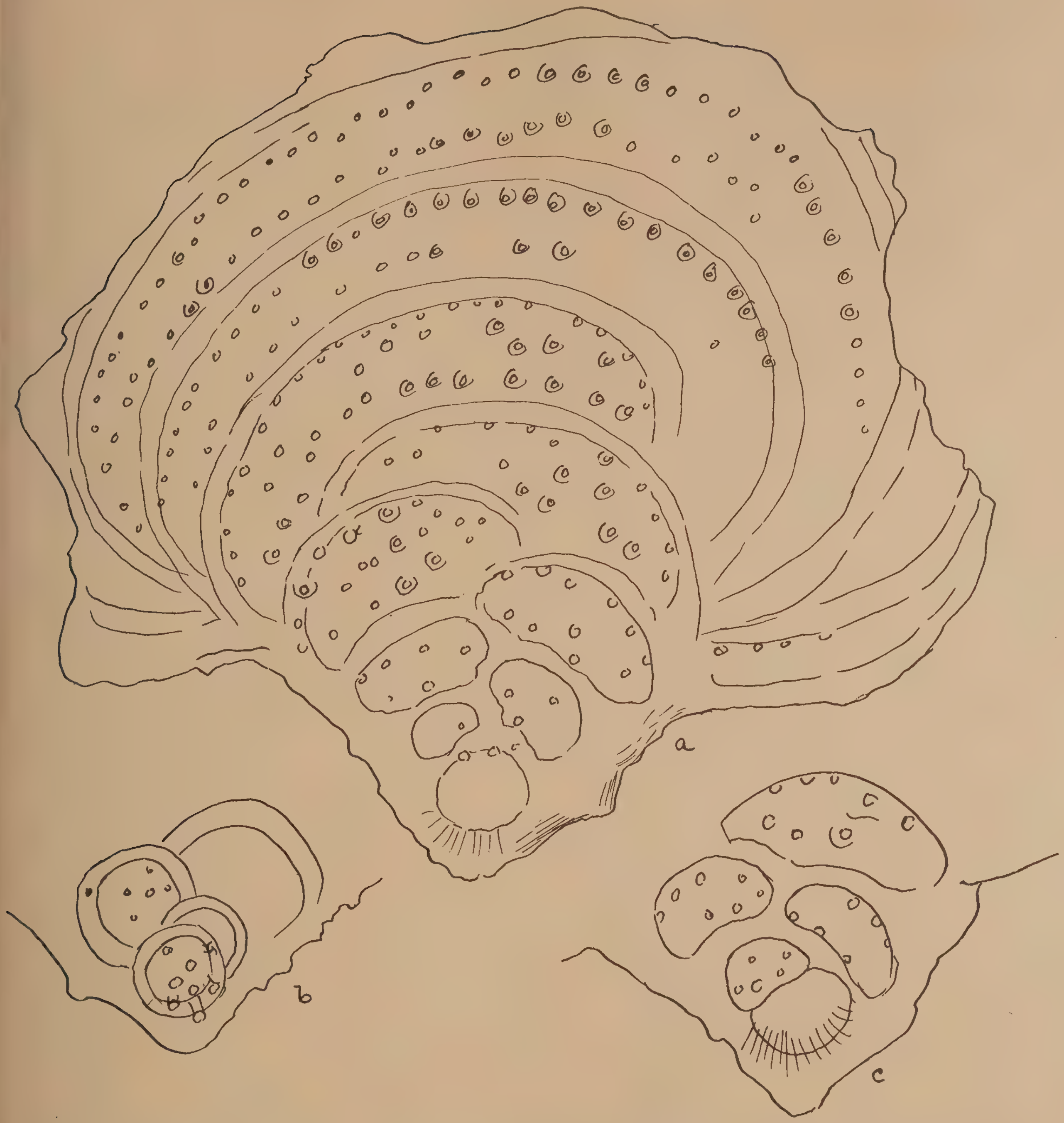


Fig. 15. *Valvopavonia flabelliformis.* a, small specimen, convex side; b, initial part, concave side, showing large pores in proloculus; c, convex side, showing fine pores in proloculus; × 432.

Genus **Valvobifarina**

The genus *Bifarina* cannot be maintained any longer; too many quite different species, belonging to different genera, have been gathered into this genus. Thus I have created a new genus for those forms which undoubtedly are related to the *Valvulinidae.*

The type of the genus is *Valvobifarina mackinnoni* (Millet).

Valvobifarina mackinnoni (Millet)
(Figs. 16, 17)

This species, always reported as very rare, was found in the Siboga-material in many specimens, at 1° 51′ S., 99° 36′ E., depth 683 fathoms, at 2° 17′ S., 99° 27′ E., depth 377 fathoms, and at St. 49a.

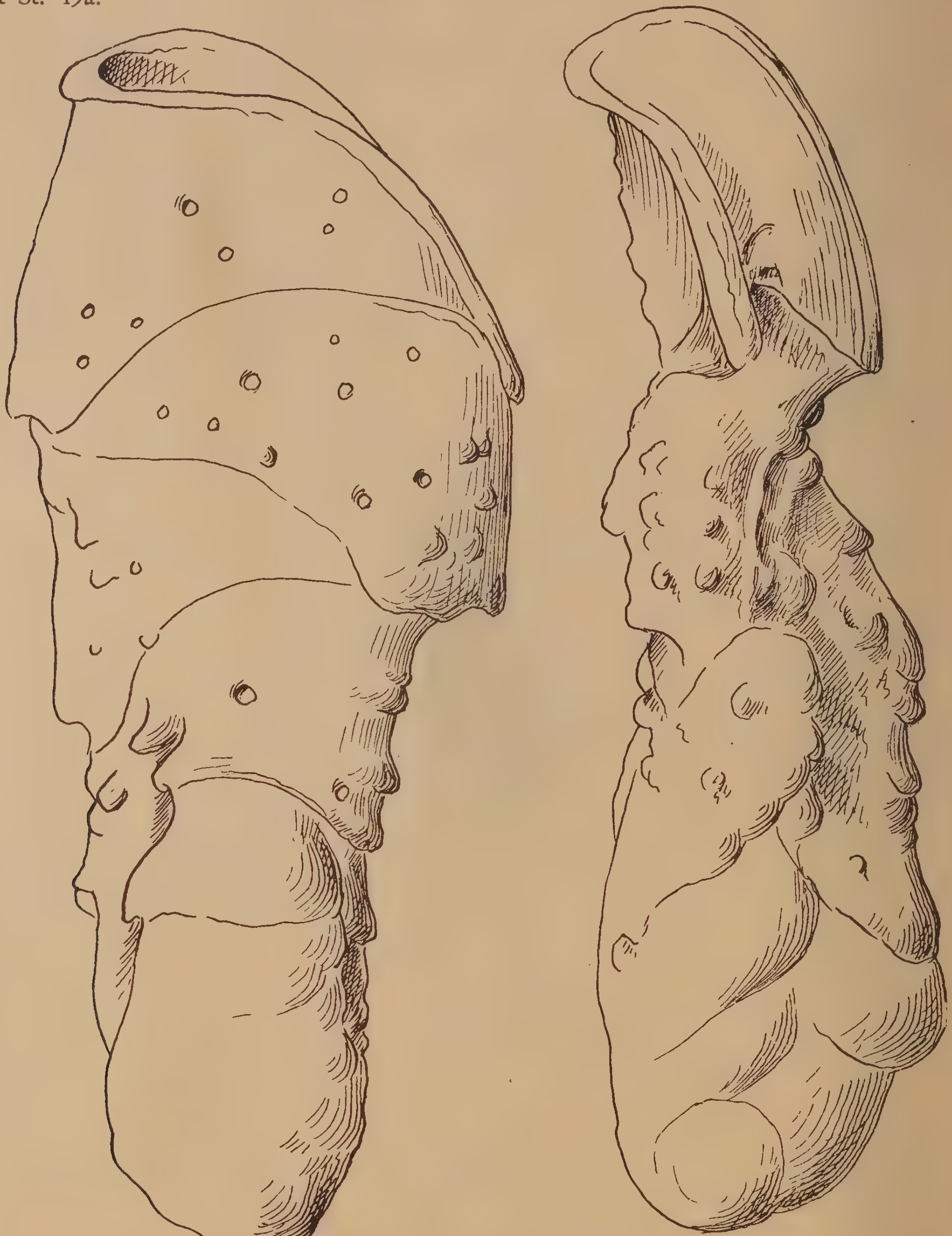


Fig. 16. *Valvobifarina mackinnoni*. Megalospheric specimen from two sides; × 480.

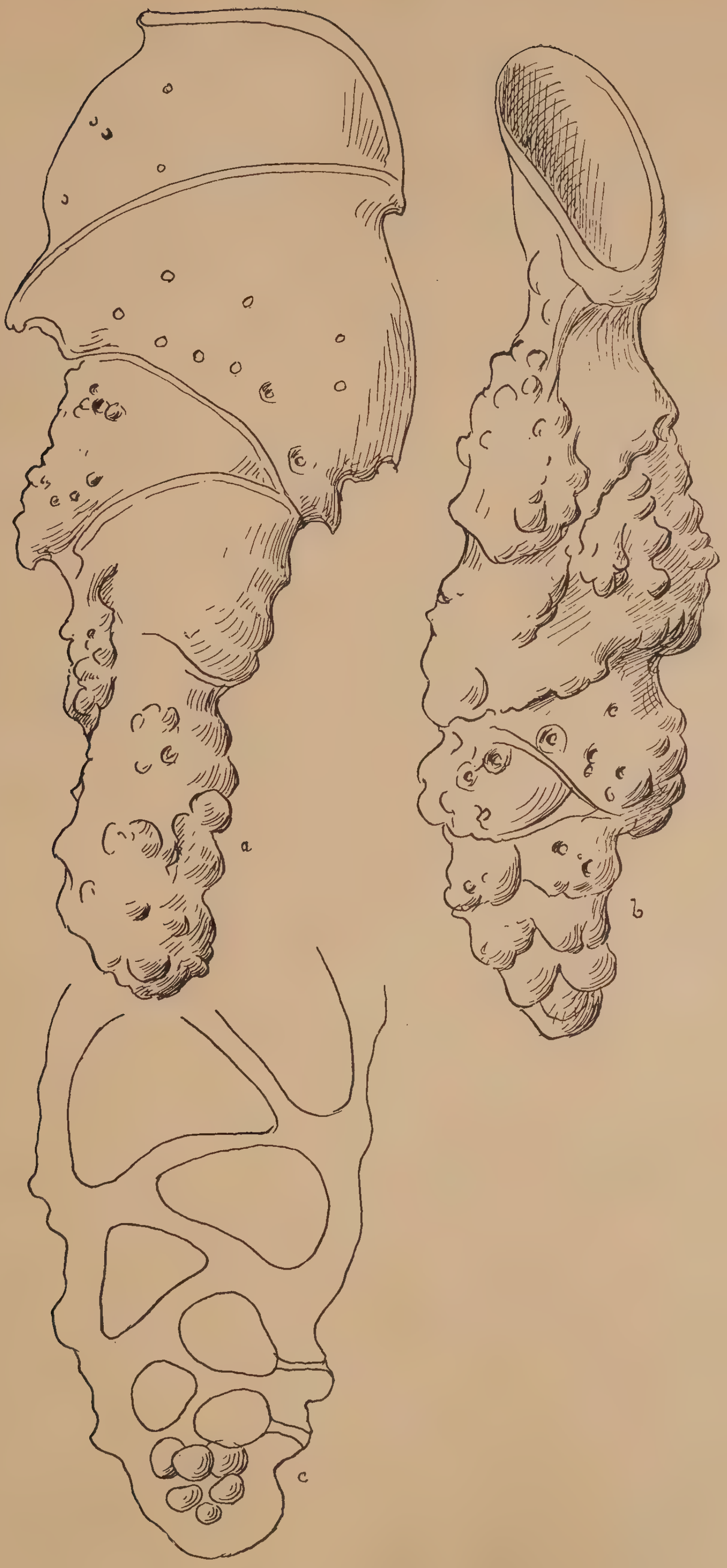


Fig. 17. *Valvobifarina mackinnoni.* a and b, microspheric specimen; c, section, showing triserially arranged initial part. × 360.

One specimen was microspheric, the other were megalospheric. The microspheric specimen had a proloculus of 8 μ diameter, the megalospheric specimens showed a diameter of about 20 μ. In the microspheric specimen the proloculus was followed by two sets of biserial chambers (Cushman, 1937, special Publ. Lab. Foram. Res., p. 201 mentioned already the possibility of this triserial arrangement) which are followed by three rows of biserial chambers, while two chambers more or less uniserially arranged form the apertural end of the test. In the megalospheric form only a single set of triserial chambers is found, followed by four sets of biserial type, with at least two chambers of the uniserial arrangement. The biserial part of the shell is contorted generally, so that the endchambers are found in a plane forming an angle of 90° with the first biserial chambers. This contortion is common among several species of *Gaudryina* and allies.

The wall shows some scattered coarse pores and several peculiar knobs; they consist of a somewhat arenaceous chalky matter, as is found in several species of the genus *Siphogaudryina,* such as *Siphogaudryina stephensoni* Cushman, and those species which earlier were called *Bolivinita eleyi* (Cushman), which I showed to be also related to *Siphogaudryina.*

All those characteristics lead to the conclusion that the species *Bifarina mackinnoni* (Millet) must be called by another generic name; as I believe it to belong to the *Valvulinidae,* on account of the pores, I have called it here *Valvobifarina,* though the aperture is of a wider construction than in most species of the *Valvulinidae.* But in other species too the aperture is an elongate opening, standing transversely on the suture of the chamber, as it is in this species. The total absence of an indication of a toothplate shows, that the species has no relation whatever with the genus *Bolivina.*

Sub-Ordo **Protoforaminata**

To this sub-ordo I bring all those families, in which the aperture stands in one way or another in connection with a toothplate and in which no second aperture is developed or no tendency is shown to develop such a second aperture.

In this group the tendency is developed to coiling along an axis with a high speed, so that many forms become even biserially or uniserially arranged in respect to their chambers.

This Sub-ordo consequently encloses the families *Valvulinidae, Bolivinidae, Buliminellidae, Buliminidae, Uvigerinidae* and *Cassidulinidae.* Most of these families show fine pores in their walls, and in no case known deuteropores have developed.

Each of these families shows typical features which characterise at once the families. In the *Valvulinidae* the walls are finely arenaceous in most cases, whereas the toothplate is a plate, covering the apertural opening partly. In the *Buliminidae* the arrangement of chambers is triserial, but in some cases it has become biserial in later parts of the test or even uniserial. The aperture always is a loop-shaped opening but for some highly developed and adapted species. In the *Buliminellidae* the aperture is very narrow, though loop-shaped, and often axially placed, whereas the coiling of the chambers is not with such a high pitch as to become triserially arranged. In some forms it becomes, however, biserial. In the *Uvigerinidae* the aperture always shows a typical neck, often with phialine lip, and the toothplate always is very typical and elongate. Here in most cases the outer wall is ornamented. The speed of coiling leads to triserial arrangement, in some cases becoming uniserial.

In the *Virgulinidae* the aperture always is loop-shaped, and the walls are always extremely thin; the coiling begins with a triserial arrangement, but often it soon becomes biserial. In all cases the walls are hyaline and transparent. In the *Cassidulinidae* the walls on the contrary are always opaque, and the coiling always shows the tendency to become biserial. In many cases this biserially arranged test once more is coiled, as its axis is coiled up in a flat spiral. In a single genus (or some genera) the tendency is shown to become uniserial. The toothplate is always of a rather simple type, apparently having the function to protect the aperture at the inner side from intruders from the outer world. In many forms an ornamentation of the test by means of spines is developed.

The 5 families of the Protoforaminata did not develop forms, standing beyond their family-characteristics. They are closed families, except for the *Valvulinidae,* the mother-family of them all, and from all other Dentata. This closed condition of these families is established once more in the fact, that even their oldest representants show the typical features of the family, from which later forms have scarcely distanciated. So, recent *Bolivina,* though often developed into *Rectobolivina* and *Loxostoma,* in main characters are alike Jurassic species. From Jurassic *Valvulina* the *Bolivinidae* have developed; *Buliminella* is known downwards into Cretaceous time; they cannot have developed, as Cushman suggests, from *Terebralina.* For this genus lacks any trace of chambers, and it is impossible to think, that at one time abruptly septa were formed in such a form. May be, that Oligocene *Turrilina* is allied to *Buliminella,* but in opposite manner: deriving from *Buliminella.* The *Buliminidae* have been recorded in the Jurassic; but it may be, that these Jurassic forms belong to *Praebulimina.* The *Uvigerinidae* developed in the Upper-Cretaceous, and show an apertural condition, which also is developed in many species of the *Valvulinidae* (*Listerella* f.i.). *Virgulinidae* have been mentioned from the Lower Cretaceous upward, but these species have to be studied once more in respect to their inner structure. The *Cassidulinidae* have developed from the Upper-Cretaceous upward.

So in all these families that of the *Valvulinidae* is the older one, and thus can be regarded in this respect too as the mother-family. And it is a remarkable fact, that in all these families, obviously deriving from the *Valvulinidae,* the arrangement of the chambers and the shape of the aperture is once more found in the *Valvulinidae.* Genetic tendencies repeat themselves in these different offsprings, surrounded by newly adopted tendencies, may be, but always shown in one way or another.

Family *Bolivinidae*

The family of the *Bolivinidae* developed obviously from *Virgulina* forefathers. The triserial arrangement of the first chambers was totally lost, and most members of the family show only a biserial arrangement which in *Rectobolivina* becomes even uniserial in the later part of the test. The pores of more primitive species are fine, but more developed species get a thicker wall and consequently the pores grow larger. The general shape of the toothplate has been fully and well described by Höglund (l.c. 1947, p. 261-262, textfig. 276). In *Bolivina* it shows an attached side, and a folded free part, forming the tooth in the aperture. In forms, which tend to become uniserial, as *Loxostoma,* the toothplate shows two free sides, as the attached one is running upward and frees itself from the basal wall of the chamber; in *Rectobolivina* the plate may become a more or less twisted totally free plate, without a folded free part. I must point out here, that in several groups of *Bolivina* offsprings may have been formed, which show the characteristics of *Loxostoma* and *Rectobolivina,* so that these genera are not of a real generic value, as both consist of very different species.

In the genera *Discobolivina* nov. gen. and *Bitubulogerina* the early part of the test is more or less coiled along the longer axis of the test. This indicates that these genera belong at the bottom of the family, as they show characters, which are also found in the *Virgulinidae*. The *Discobolivinae* are very important, as they form the root of the genus *Conorbis*, which has been regarded as one of the ancestral groups of the *Rotaliformes*. The genus *Bitubulogerina* is placed here among the *Buliminidae*, as the coiled part is more or less triserial in this genus. *Discobolivina* was shown to be a real Conorbide genus, which has nothing to do with *Bolivina*, so that its species, one of which was called *Bolivina ambulacrata* Moebius, do not belong here.

I showed, that Ehrenberg has established the genus *Loxostomum* for quite a different group of Foraminifera as is believed by recent authors. The genus was erected for those species, now known as *Bolivinita eleyi* and *B. planata*. In reality, according to rules they have to be called *Loxostomum*; this would be of no real importance as to nomenclature, as I could prove, that genera as *Rectobolivina* and *Loxostoma* do not have a real meaning as genera.

Genus **Bolivina**

This genus even in the microspheric generation shows a biserial arrangement of chambers from the beginning. The proloculus in megalospheric forms always possesses very fine pores, such as are occurring in *Virgulina*, but afterwards the pores may become much larger, up to coarse pores; in those forms which show a thin wall and a more or less simple structure of it, pores are rather fine, but not so fine as in *Virgulina*; but even in cretaceous species with thicker walls and some structure on it, pores may be already coarser. So species with fine pores, such as *Bolivina antiqua*, may occur together with species with coarse pores, such as *Bolivina byramensis*, in the Oligocene of the Netherlands. The primitive state is, of course, that with smaller pores.

More primitively built species, especially those from tertiary and cretaceous deposits, show always a primitively formed toothplate. The Jurassic species, such as *B. liassica* and *B. rhumbleri*, always show very primitive plates. I have given here an instance in *B. rhumbleri*. This plate, already analysed by Höglund (Foraminifera in the Gullmar Fjord and the Skagerak; Zool. bidrag f. Uppsala, Vol. 26, 1947, p. 262-263) in its most primitive development shows one part which is attached to the bottom of the chamber, then running upward to the next aperture, while its base is situated at the proximal border of the foregoing foramen; this attached part forms the opposite border of the next aperture, opposite in respect to the border of the former aperture, from which it emerges. The free part folds itself up, forming in this way a rounded backside of the plate, and forms a somewhat flag-like tooth which may or may not emerge from the aperture. In primitive forms this tooth has totally smooth and regular borders. It was found in *B. rhumbleri*, *Bolivina antiqua*, *Bolivina pygmaea* (in the latter species the upper margin of the tooth was sometimes irregularly sawed).

A somewhat higher development of the toothplate is found, when the backside of the plate is not straight, but somewhat sigmoidally in shape. All other features are the same. It occurs in *Bolivina seminuda*, *Bolivina tortuosa*, *B. inconspicua*.

In all formerly mentioned plates the folding of the plate begins at its base. In other, higher forms, this folding contains only a part of the total plate, thus beginning somewhat about the middle of the plate upward. In most of these species sawings of the free border of the tooth are found (a sawing of the primitive toothplate itself occurs in *Bolivina byramensis* from the Miocene). Forms of this group are *Bolivina vadescens*, *Loxostoma beyrichi*, *Loxostoma amygdalaeforme*. In all mentioned species the backside of the plate remains straight throughout.

The highest form of development, only occurring in recent types of the genus, is reached, when the back of the toothplate begins not at its base, but higher up, and thus a basal hook is formed between the toothplate itself and is folded back. This form, with more or less denticulation of the free border of the tooth, according to the species, is found in *Bolivina alata, Bolivina spinescens, Bolivina albatrossi, B. subreticulata, B. hantkeniana, B. quadrilatera, B. compacta, Rectobolivina bifrons.*

In the biserial chambers of *Loxostoma* the toothplate shows, as already stated, the characteristics of some of the forms of *Bolivina*; but in those chambers which show the tendency to become uniserial in this sub-genus, the folded part of the plate becomes reduced, while the attached side of it becomes more or less free, and often somewhat folded too. It was found, that in all forms of *Loxostoma* studied, the toothplate of the bolivina part showed a more or less primitive character; thus it is probable, that the higher developed species of *Bolivina* did not give rise to *Loxostoma,* but even the more primitive ones, with a simple toothplate. Only such kind of toothplate can give rise to the reduced one. And it may be even this toothplate which is the leading agency in the forming of the shape of the surrounding chamber as well as of its aperture. I believe even, that the toothplate is formed first, the surrounding chamber afterward.

In the sub-genus *Rectobolivina* the toothplate of the earlier chambers likewise is of the primitive type, but in the uniserial chambers it becomes likewise reduced to a simple plate with both sides often somewhat folded, and both sides free; only the base is attached to the border of the former aperture.

As was pointed out already by Höglund, the toothplates of the successive chambers in *Bolivina* alternate in position. The tooth of each plate runs more or less along the border of the next aperture opposite to the border of the former aperture, from which it emerges. In *Rectobolivina* likewise the toothplates alternate, which is easily seen, when the test is observed from aside, straight on the bolivine plan of the test. Then one may observe, that a plate runs from one side of an aperture toward the opposite side of the next one; it can be easily observed in *Rectobolivina columellaris.* This alternation in all species of the whole genus (even in *Rectobolivina virgula* the reduced toothplate alternates) leads to several consequences. In the first place it is obvious, that this alternation has something to do with biserial arrangement of the chambers. This alternation in the chambers is found in quite another way in those genera, allied with *Bulimina.* In these buliminine genera the alternation is always so, that the next chamber shows a toothplate, directed in angle of 120° towards that of the former chamber. Here lies a very important difference in structure, by which difference offsprings with uniserially arranged chambers of *Bolivina* can easily be distinguished from those, which are allied to *Bulimina.* In the former species the angle between two successive toothplates is 180°, whereas in the offsprings of *Bulimina* they preserve their angle of 120°. In the species studied belonging to the genus *Siphogenerina* the angle was always 180°, and thus they belong to the sub-genus *Rectibolivina.* As a matter of fact, the so-called "sipho" of *Siphogenerina* does not exist at all, but is nothing else but a falsely understood toothplate. When seen in face, the toothplate with its folded borders in many cases suggests a sipho; but when seen from aside, it is a flattened or twisted plate. In the genus *Sagrina* the toothplate forms transverse septa in the chambers, thus giving the genus a more complicate character.

The species in this chapter are arranged along the line of development of the tooth-plate (Fig. 18), for I am convinced that this will be the most natural arrangement. The reduced toothplates

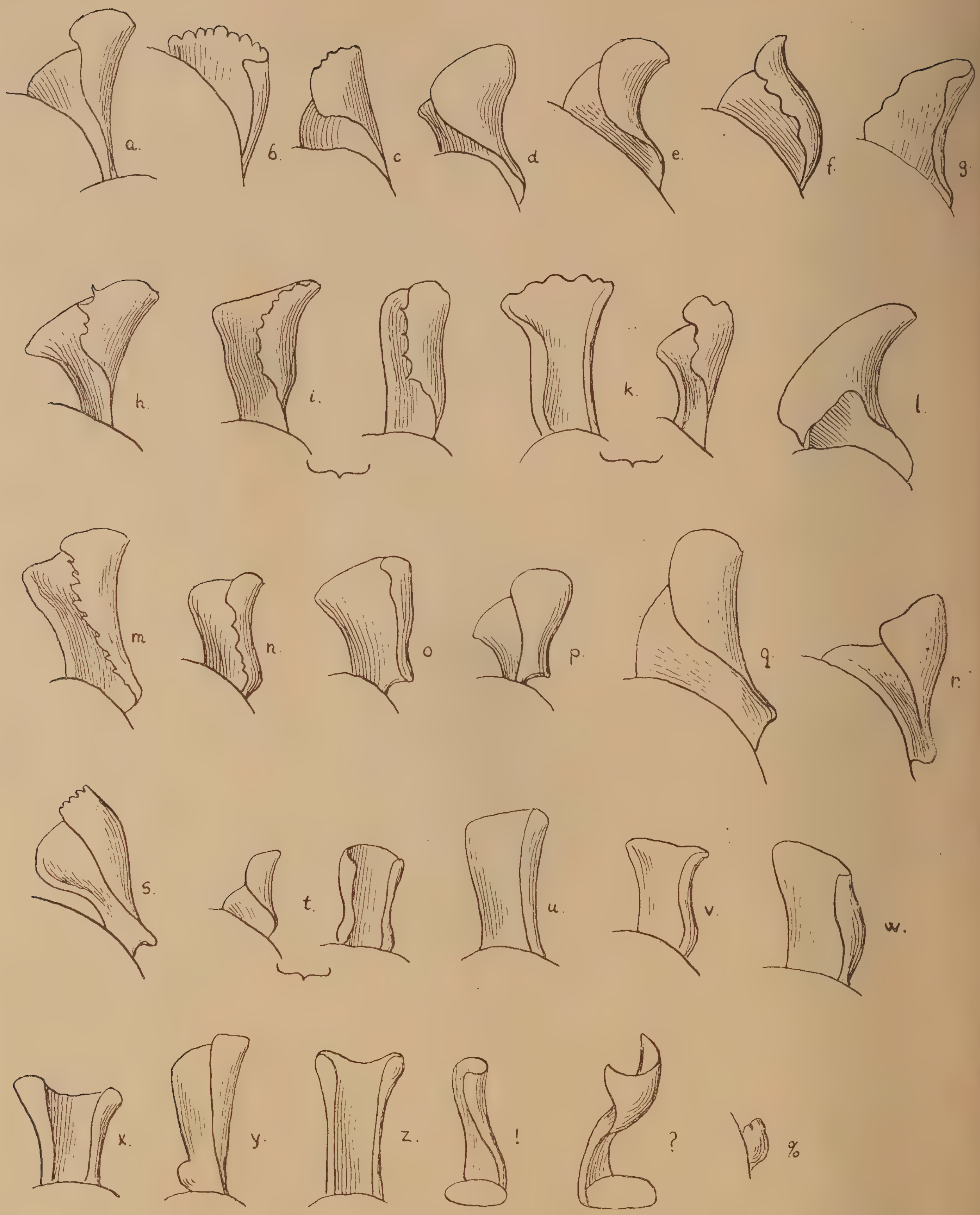


Fig. 18. Toothplates of *Bolivina, Loxostoma, Rectobolivina, Bifarina.* — First row: primitive plates; a, *Bol. antiqua*; b, *B. byramensis*; c, *B. pygmaea*; d, *B. seminuda*; e, *B. tortuosa*; f, *B. inconspicua*; g, *B.* cf. *"beyrichi"*. — Second row: tests with ornamented free part, h, *Bol. vadessens*; i, *Loxostoma beyrichi*; k, *Lox. amygdalaeforme*; l, *Bol. spec.* (after Höglund). — Third row and first fig. of fourth row: plates with basal hook; m. *Bol. alata*; n, *B. spinescens*; o, *B. albatrossi*; p, *B. robusta*; q, *B. hantkeniana*; r, *B. quadrilatera*; s, *B. compacta.* — Fourth and fifth rows; t, *Rectobolivina bifrons*; u, *R. strigosum*; v, *L. cuneata*; w, *L. karreriana*; x, *Bifarina fimbriata*; y, *Lox. porrectum* (after Höglund); z, *Rectob. dimorpha*; !, *R. nov. spec.*; ?, *R. columellaris*; %, *R. virgula.* No special enlargement.

of *Loxostoma* and *Rectobolivina* are mentioned in the last place, as it will be obvious that these genera have derived from real *Bolivina. Rectobolivina fimbriata,* formerly called *Bifarina,* is here mentioned under this genus, as it shows all characteristics of real *Rectobolivina. Rectobolivina virgula* stands apart, as here the toothplate is so far reduced, that even in the biserial chambers it hardly can be found. *Bolivina quadrilatera,* formerly known as the type-species of the genus *Bolivinita,* showed to be a typical and quite normally built *Bolivina,* but for the two wings running along each chamber, which character is already accounted for in its specific name, so that a new generic name is not at all necessary; moreover I was able to prove in another paper, that the fossil species *Bolivinita eleyi* Cushman does not belong to this group, but that it is in reality a *Siphogaudryina.* Several species of which abundant material was available could be studied statistically in respect to their generations. It was found that often the two megalospheric generations overlap each other in the frequency-curve, as has been shown already by Höglund (1947). So it was necessary to add other characteristics in correlation with the size of the proloculus, to analyse those generations. Such correlated characteristics showed to be in *Bolivina* the total number of chambers, and in *Rectobolivina* that of biserial, as well as that of uniserial chambers. In this way it could be easily proved, that in this group, according to my theory of trimorphism, three different generations are found.

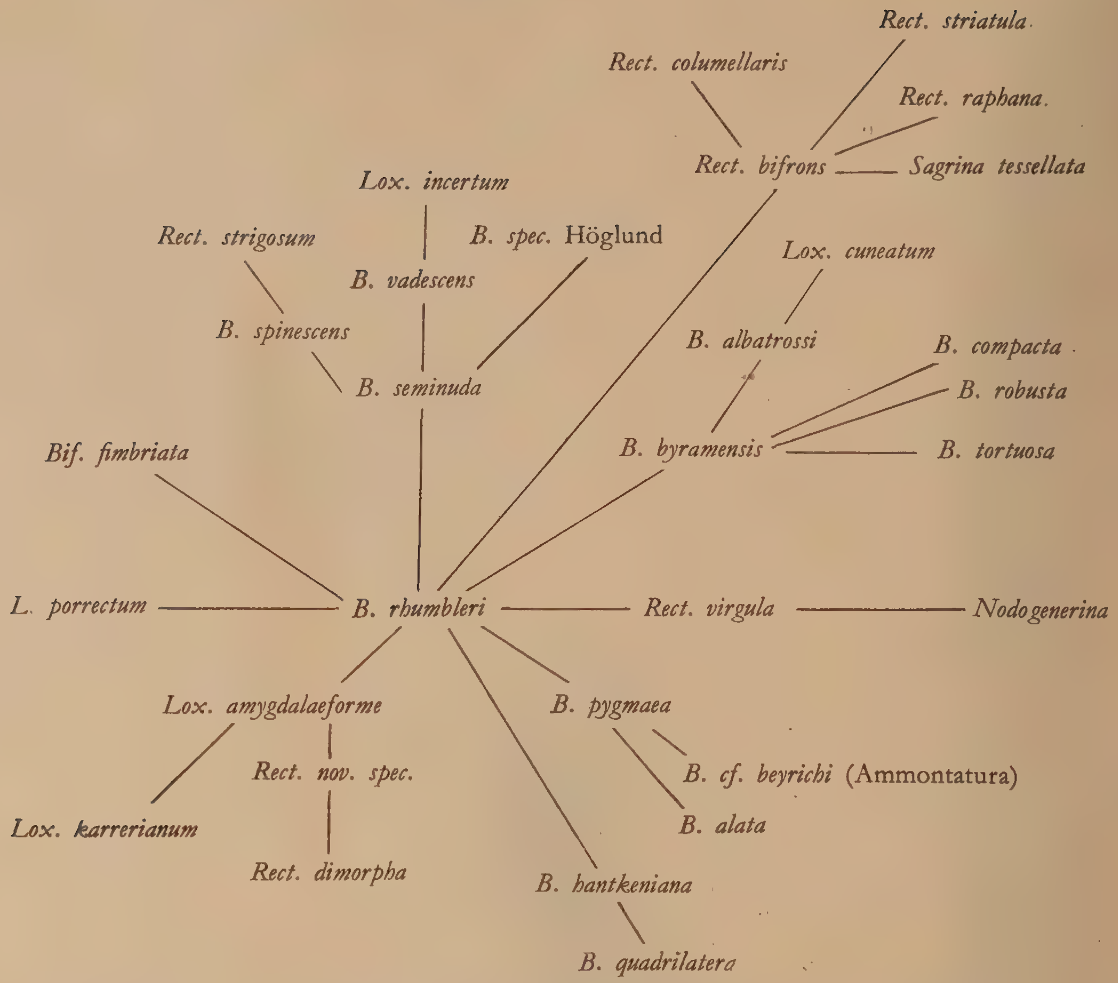
The proloculus, even in megalospheric specimens, in all species shows only very fine pores, if at all, even in those species, in which coarser pores are found in the other chambers. Thus the proloculus shows the character of the forefathers of *Bolivina,* viz. *Virgulina* (*Praevirgulina*).

In several species of *Bolivina* the three generations show differences in shape, ornamentation of the test, and other characteristics which may even give rise to the creation of different specific names for these generations of a single species; but the toothplates keep in the different generations of a single species their typical characters which peculiarity is another reason to regard the shape of the toothplate as a more reliable characteristic than outer ornamentation.

The following diagram shows the relationship of the different species of *Bolivina,* of which the toothplate is known now. As this diagram proves, the sub-genera *Rectobolivina, Bifarina* and *Loxostoma* cannot be regarded as groups consisting of related species; in very different groups of *Bolivina* the tendency to become uniserially arranged is found, and thus these subgenera have not the qualities of closed groups, as a real sub-genus should have. Secondly the diagram shows, that species with a simple toothplate always stand in the midst of explosion, while those with highly organised plates or with reduced ones stand at the periphery.

In this scheme of relationship among the bolivine Foraminifera in this way very typical groups are distinguished. In the group, allied with *B. seminuda,* the test is always fairly thick, very hyaline, smooth and pierced by very fine pores. The group around *Lox. amygdalaeforme* on the other hand has always rounded, regularly placed, large pores, and in all species, belonging to that group, the test shows a yellowish colour in transmittant light. This colour is very typical; the test in this group in all cases is a thick one. In the group around *B. byramensis* the test shows always an irregular arrangement of the coarse pores, while the thick test in most cases forms protuberances at its surface, leading to sunk-down pores in the older parts of the tests. In the *B. pygmaea*-group the pores are mostly distinct, the test is always very hyaline, and often tending to form ridges and wings at its surface. It is possible, that *B. beyrichi* (*Loxostoma*) belongs to this group too. The groups *spinescens-strigosum, conspicua-fimbriata* and *virgula-nodogenerina* show typical characteristics, which point to specialization in one or another direction.

BOLIVINIDAE


Rect. striatula
Rect. columellaris
Rect. raphana
Rect. bifrons
Sagrina tessellata
Lox. incertum
Rect. strigosum
B. spec. Höglund
Lox. cuneatum
B. vadescens
B. spinescens
B. albatrossi
B. compacta
B. seminuda
B. robusta
Bif. fimbriata
B. byramensis
B. tortuosa
L. porrectum
B. rhumbleri
Rect. virgula
Nodogenerina
Lox. amygdalaeforme
B. pygmaea
Rect. nov. spec.
B. cf. beyrichi (Ammontatura)
Lox. karrerianum
B. alata
Rect. dimorpha
B. hantkeniana
B. quadrilatera

As the literature of this genus *Bolivina* and its allies has been given in extenso by Cushman in his paper A Monograph of the Foraminiferal subfamily *Virgulinidae,* Lab. Foram. Res., Special Publ. No. 9, 1937, for reasons of space literature has not been mentioned in the description of each species, when unnecessary. I refer the reader to this paper of Cushman.

Geographic distribution of the *Bolivinae*

When we take the "Wallace's line", going through Maccassar-Strait, as border between the western and eastern parts of the Archipelago, a striking difference exists between these two parts. Some species are spread all over the Archipelago. They are:

B. inconspicua	Pacific
B. quadrilatera	Pacific, Atlantic
B. compacta	Mediterranian, Atlantic, Pacific
R. dimorpha	Pacific, Atlantic, Indian Ocean
R. columellaris	Atlantic, Indian Ocean, Pacific
Bif. fimbriata	Pacific
B. robusta	Atlantic, Pacific, Indian, Antarctic Ocean.

From these species most are known to be spread over the whole world.

Typical for the western part of the Archipelago are:

B. alata	Mediterranean, Pacific
B. tortuosa	Indian Pacific
B. spinescens	Pacific
Lox. strigosum	Pacific
B. albatrossi	Atlantic, Pacific
B. robusta without spine	Widely spread
R. virgula	Atlantic, Pacific
Lox. cuneatum	Pacific
B. vadescens	Pacific.

From these species most are known from the Pacific only.

Typical for the eastern part are:

B. robusta with spine	Widely spread?
R. bifrons	Pacific
R. striatula	Pacific
Lox. amygdalaeforme	Pacific
B. hantkeniana	Pacific
B. pygmaea	Pacific, ?Atlantic
B. "beyrichi"	Eastern Pacific
Lox. karrerianum	Pacific, ?Atlantic.
B. seminuda	Eastern Pacific.

From these species most are known only from the Pacific.

This record leads to the following conclusions:

The bolivine Foraminifera, recorded all over the Archipelago, are mostly species, which are found all over the world; they show no particular geographic distribution. The species, mentioned for the western part of the Archipelago, are mostly found only in the Pacific regions, while some of them are recorded from the Indian and the Atlantic. They clearly show the influence of the Asiatic-continental shelf. Those typical for the eastern part are only with certainty known from the Pacific, and often only from its eastern part. Some of these species show the particularity, that they form the most primitive species of their groups, viz. *B. seminuda, Rect. bifrons, B. pygmaea, Lox. amygdalaeforme, B. hantkeniana.* This is in agreement with my results in my paper on the Foraminifera of the Malay Archipelago, gathered by Dr. Th. Mortensen (Vidensk Medd. fra Dansk naturh. Foren., Vol. 93, 1933, p. 72) as I stated: "... a sharp contrast is to be found between the eastern and the western part of the Archipelago of East-India. Especially in the eastern part of the region the Foraminifera show a nearly fossil (Tertiary) habitus, as a whole."

The wonderful species *Sagrina tessellata* is only known from the eastern part of the Archipelago. It was found also in lower Tertiary.

Cushman mentions (Bull. 100, 1921):

Bol. robusta from 5° N to 5° S and from 118° to 126° E, thus around Celebes.
Bol. schwageriana from 4° N to 3° S and from 118° to 127° E, around Celebes.
Bol. nobilis 2° S, 118° E, Gulf of Tomini.

Bol. karreriana 3° S, 126° E and 2° S 118° E, Macassar Strait, Banda Sea.
Bol. hantkania 4° N to 2° S and 118-119° E, coast of Bornea to Celebes Sea.
Bol. compacta, point of Minahassa.
Rect. dimorpha 2° S, 118° E, Strait of Macassar.
Rect. striatula 0° N to 3° S and 118-127° E, around South Celebes.
Rect. bifrons 6° N to 8° S and 118-128° E, Celebes Sea and around Celebes.
Rect. columellaris 6° N to 3° S and 120-126° E, Celebes Sea and Northern Celebes.

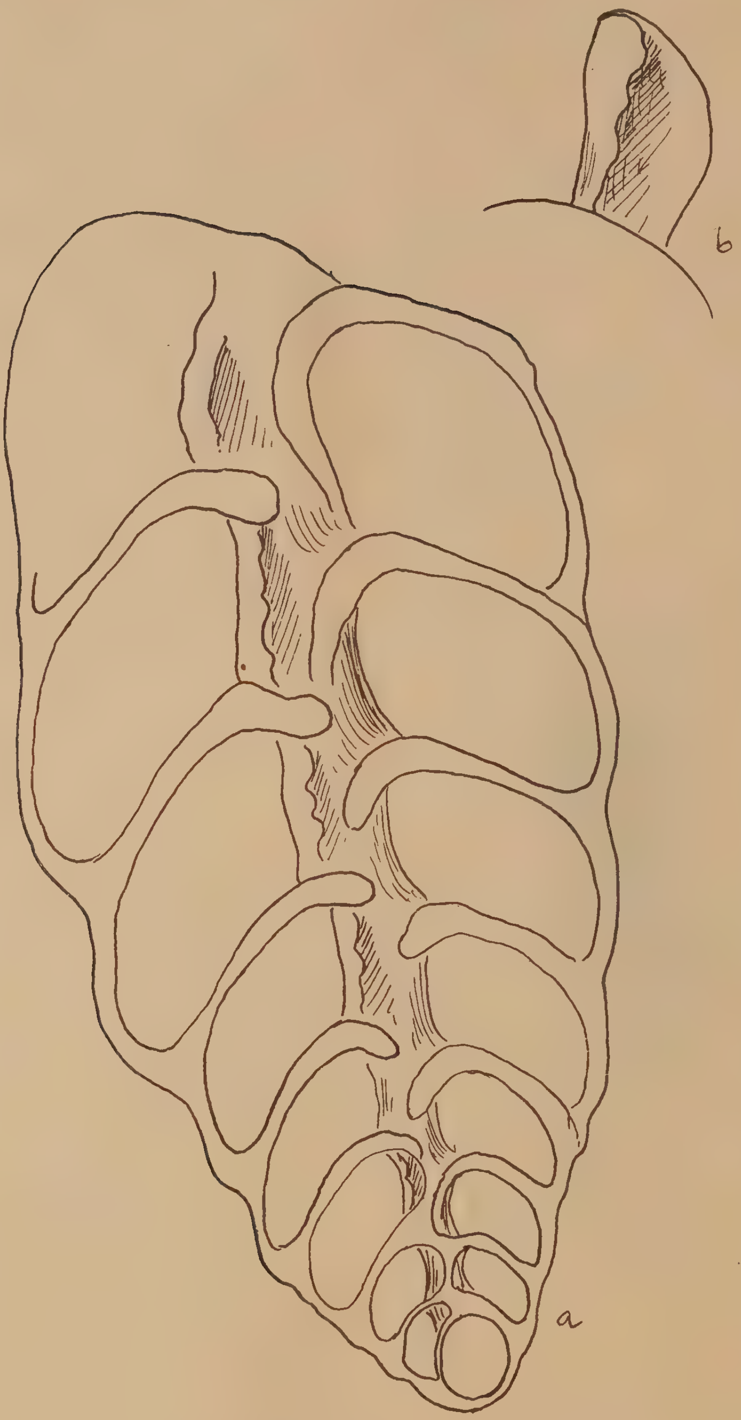


Fig. 19. *Bolivina rhumbleri* Franke from the Lias, Netherlands. a, Section, showing toothplates; b, toothplate × 480.

Bolivina rhumbleri Franke
(Fig. 19)

In his paper on the *Virgulinidae* (1937) Cushman mentions only a single species from the Jurassic, *Bolivina rhumbleri* Franke. Two species are known to me from the Lias of the Netherlands, *Bolivina rhumbleri* and *Bolivina liassica* Terquem. Cushman does not mention the latter species.

Sections made it sure, that the species *Bolivina rhumbleri* is a real *Bolivina*, with very fine pores throughout over the test, as they are found only in the proloculus of recent species. The aperture is a low, somewhat rounded slit at the suture of the last-formed chamber and directed in the breadth of the test, as usual. The toothplate is a very primitive one, narrow, with a very narrow and smooth free folded part. It shows much resemblance with the toothplates of cretaceous *Buliminella* and of some recent or primitive *Bolivina*-species, such as *Bolivina antiqua* from the Miocene and *Bolivina pseudogoësii* nov. spec. from the Caribbean.

From these unornamented species, which in all forms show the biserial arrangement of the chambers from the beginning, all other Bolivine species must have been derived. The fact, that true *Bolivinae* occur in the Jurassic strata gives us the possibility to believe, that the biserial arrangement of chambers is a primitive one, and that it may be, that the triserial and polyserial arrangement of chambers is a more advanced stage in development. So it may be, that genera as *Buliminella* and *Conorbis* have been derived from *Bolivina,* and not reversely. It is moreover a remarkable fact, that those Jurassic *Bolivinae* are lacking any trace of a twisted initial part, as is found in *Virgulinae.* This points too to a development of *Virgulina* from *Bolivina,* and not to one of *Bolivina* from *Virgulina. Virgulina* moreover is known from the Lower-Cretaceous upward.

Bolivina seminuda Cushman
(Fig. 20)

This species was found abundantly at St. 10° 00′ S., 123° 19′ E. Savu-sea, at a depth of 453 fathoms. All specimens were megalospheric, presumably A_2. The somewhat curved test, with the numerous chambers, which are not at all inflated, with their very indistinct sutures, the typical arrangement of the pores at the initial border of the chamberwall, leaving a somewhat triangular space at the oral side free, with the nearly parallel sides of the test, and the very typical fine pores or tubercules covering the clear prolocular wall, are in all respects resembling *Bolivina antiqua* from the Miocene strata of Europe. The only striking difference lies in the toothplate, which in *B. antiqua* is a very simple one, and in *B. seminuda* is slightly more complicate. In *B. antiqua* it is a simple cornetshaped building, running straight up from the margin of the foregoing aperture, while in *B. seminuda* it shows a more fan-shaped structure in respect to the free part, while at its base it shows already the typical hook, though not so prominent as in most modern *Bolivinae.*

All these common features, however, point to the conclusion, that *Bolivina seminuda* is nothing but the modern offspring of *B. antiqua.*

The shellwall of *B. seminuda* is somewhat thicker than that of *B. antiqua,* and thus the pores are larger in the former species; the whole shell is stouter too. While shells of *B. antiqua* measure 0,30 mm with about 20 chambers, those of *B. seminuda* have a length of 0,35 mm with the same number of chambers. The width of shells of *B. antiqua* is about 0,09 mm, that of *B. seminuda* 0,13 mm. Thus the ratio between length and breadth in both is the same, about 3.

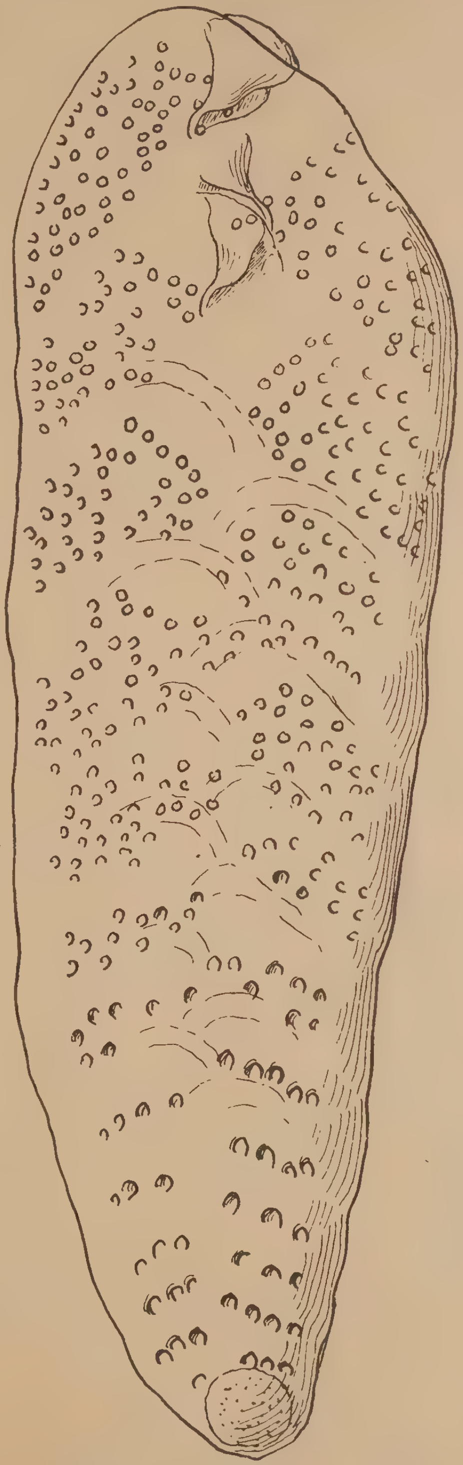


Fig. 20. *Bolivina seminuda* Cushman. Megalospheric individual, showing situation of pores and toothplates. × 480.

As one knows, that in recent species geographical distribution is of influence on the largeness of a species as well as on the thickness of the walls, geological difference equally may be the cause of those differences in texture. These differences are not large enough, to create different species. But the somewhat higher development of the toothplate in *B. seminuda* is of more significance, and may be regarded as a specific different characteristic. But it is the only one!

The species has been recorded by Hada from shallow water of Japan, and, though rarely, at three stations of the Albatross (Cushman, U.S. Nat. Mus., Bul. 161, 1942 p. 26). As the species was rather common in the station mentioned above it is not limited to colder regions.

Description of A-form:

Test elongate, slender, with very thick, hyaline and smooth walls, at first tapering, but then with nearly parallel sides. Sutures indistinct, only indicated by the lacking of pores. Chambers gradually increasing, but not much so; chambers slightly broader than high. Pores of proloculus very fine, covered by fine tubercules on the surface; pores of biserial chambers at the initial part sunken down into the thick walls and relatively large, becoming smaller toward the apertural end. Apertural part of each chamber lacking pores, so that a triangular part near the central axis of the chambers remains free from pores. Aperture a high slit at the suture; toothplate simple, folded, with a broad flaring free part, with smooth borders, somewhat protruding from the aperture.

Length of shells 0,30 mm, breadth 0,13 mm.

Bolivina ramosa nov. spec.

(Fig. 21)

This species, occurring abundantly in St. 2° 58′ S., 99° 47′ E., 928 fathoms, bottom temperature 3,8° C., resembles *Bolivina subaenariensis* from the West-Indian region, but differs in several typical characteristics.

Test elongate, slightly tapering toward the apertural end, with apical spine; depressed, with keeled margin, highest portion in the middle axis. Sutures of the chambers easily distinguishable, oblique, making an angle of about 60° with the margin, nearly straight and running into the suture of the next chamber without curving. The whole test is covered with a striate ornamentation, consisting of distinct and raised costae, which, contrary to those in *B. subaenariensis,* often branch off, when the test broadens. The pores are situated only at the proximal suture of each chamber, in the first chambers often missing, later on a single row, and in the last-formed chambers consisting of several rows. They are distinct and fine, but typical.

The toothplate is much differing from that of *B. subaenariensis.* It is a very simple one, running from the former aperture with a convex back and not with a curved back, as in *B. subaenariensis.* Moreover the free border is smooth, and not sawed.

The typical branching of the costae gave me its name: *B. ramosa.* The other differences with *B. subaenariensis* are: the straight sutures and the typical toothplate, much differing from that of the other species.

Length up to 0,35 mm.

Bolivina vadescens Cushman

(Fig. 22)

The species occurred in most samples in the Archipelago, especially in those near Flores, but always rare. It was abundant in a gathering at 5° 21′ N., 107° 14′ E., N. to Natuna-Arch., depth 43 fathoms. Cushman had it mostly from shallow water.

The species is characterised by the sigmoid sutures which are very distinct, as pores are lacking at the sutures. The walls of the chambers are totally porous, the pores are very distinct, but not coarse. The periphery is rounded, and not carinate, the aperture an open oval at the suture. But the toothplate is very characteristic, as it tends towards the *loxostome* type, as the free part begins at the middle of the plate without making any hook, and is sawed irregularly, while the attached end does not follow the basal wall but runs after a short period upwards with an arched end to the inferior end of the mouth. Microspheric shells are longer and much more pointed at the initial end, megalospheric shells have a very blunt initial end. Some specimens showed a proloculus with a diameter of about 25 μ,

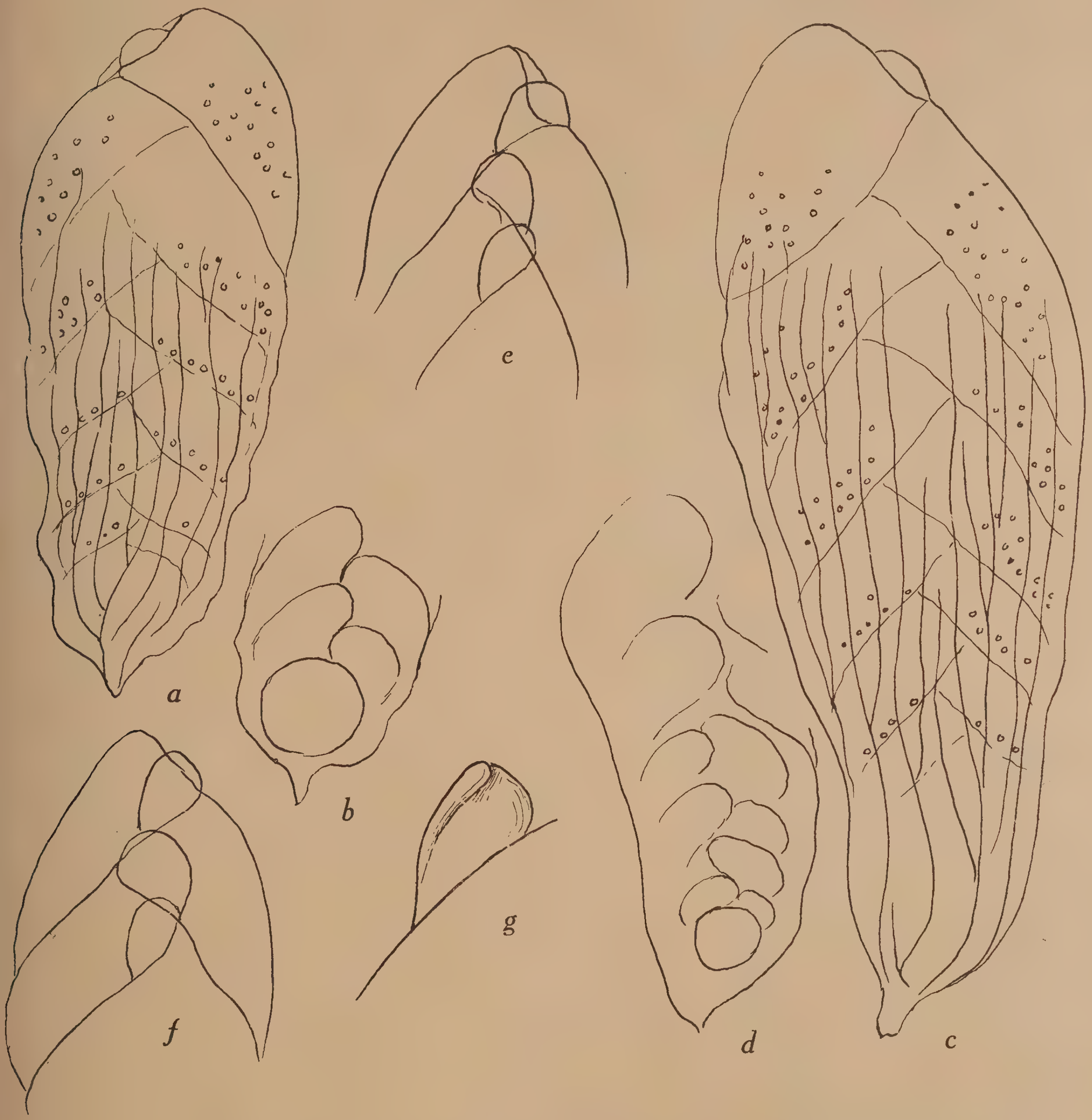


Fig. 21. *Bolivina ramosa.* a, megalospheric specimen; b, its initial end in optical section; c, megalospheric specimen; d, its initial end in optical section; e and f apertural ends in optical section; all × 480; g, toothplate, × 630.

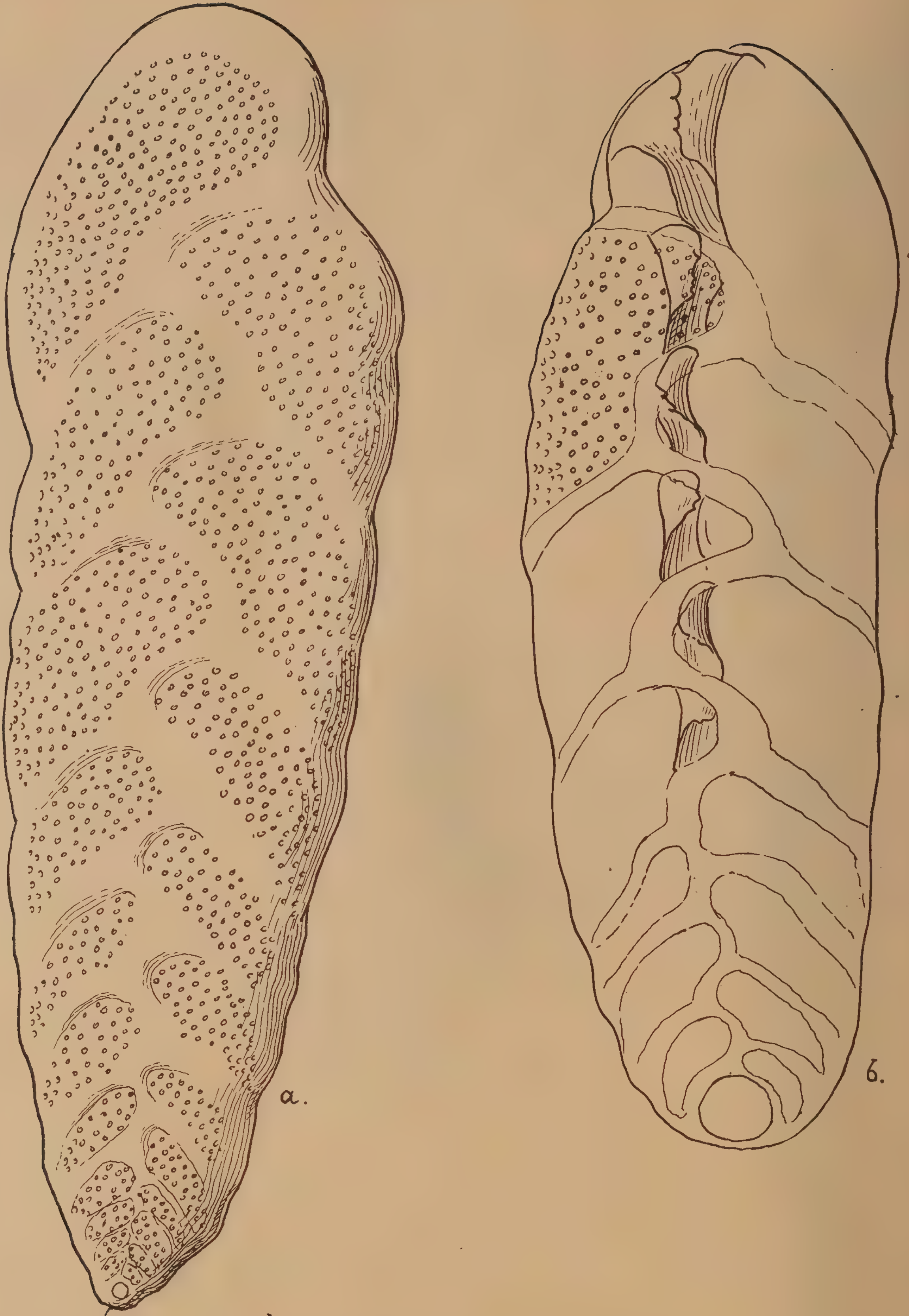


Fig. 22. *Bolivina vadescens* Cushman. a, microspheric test, from without; b, megalospheric test, showing sutures, pores of one of the chambers, and toothplates of the later chambers. × 480.

other had only 10-12 μ diameter; the microspheric shells began with a proloculus of 6 μ diameter, while the next chambers are situated beside this proloculus.

The walls are thick and very hyaline, smooth.

Length of microspheric specimen about 0,50 mm, that of megalospheric shells about 0,40 mm. Width of the shells about 0,13 mm. It has been recorded by Cushman from several Pacific stations, all of very shallow depth. The only Albatross-record is from 108 fathoms.

Bolivina vadescens in many respects resembles *B. seminuda,* but for the sutures, which are more like those of *B. antiqua,* and for the toothplate, which is, with its sawings, quite characteristic. Description of the species:

B-form. Test very slender, with pointed initial part, gradually tapering, but in the end having nearly parallel sides. Walls very smooth, with somewhat raised sutures at the initial end; oblique sutures, with an angled curve in the midst of them. Pores relatively fine, but very distinct in the smooth surface; margin rounded, with slightly inflated chambers. The chambers are high, as the aperture stands nearly in the direction of the axis of the shell, and they overlap the foregoing ones at the margin.

A-form. Resembling in many respects the B-form, but for the blunt initial end and the more parallel sides. In both forms the pores cover the whole wall of the chambers.

The toothplate is of the simple type, free part beginning about the middle of the plate, but without hook, and the free border of the tooth with sharp sawing-points; not protruding from the aperture. Length of shells up to 0,50 mm, breadth up to 0,13 mm.

Loxostoma incertum nov. spec.

(Fig. 23)

In St. 8° 15′ S., 118° 56′ E., off Sumbawa, 340 fathoms, this species was fairly common. It shows striking resemblance to *Loxostoma spinata* nov. spec. from the West-Indian region, but for the shape of the toothplate and some other minor characteristics. These differences are:

The total number of chambers in megalospheric forms is smaller, in microspheric larger than that of the West-Indian species;

the microspheric specimens do not show any spines, whereas those in the West-Indian species showed always a spinous initial suture;

the microspheric specimens are more slender, and their endchamber is somewhat higher.

Together with these minor differences, the toothplate of the East-Indian species always shows a sawed free border, whereas those of the West-Indian region show not the large sawing, but only very fine denticulations.

It may be, that these differences are but variations, as typical characters are the same. A very striking character of both species is a meandric ornamentation of the surface of the walls. The typical angle of the suture in the axis of the test is found much more pronounced in the East-Indian species than it is in the West-Indian.

May be that *Loxostoma porrectum* (Brady) is a form of this species, as some forms with small proloculus do not show any spines at the initial sutures of the chambers, and in that case are identical with the figure, given by Cushman of *L. porrectum* from the Pacific (1937, Lab.

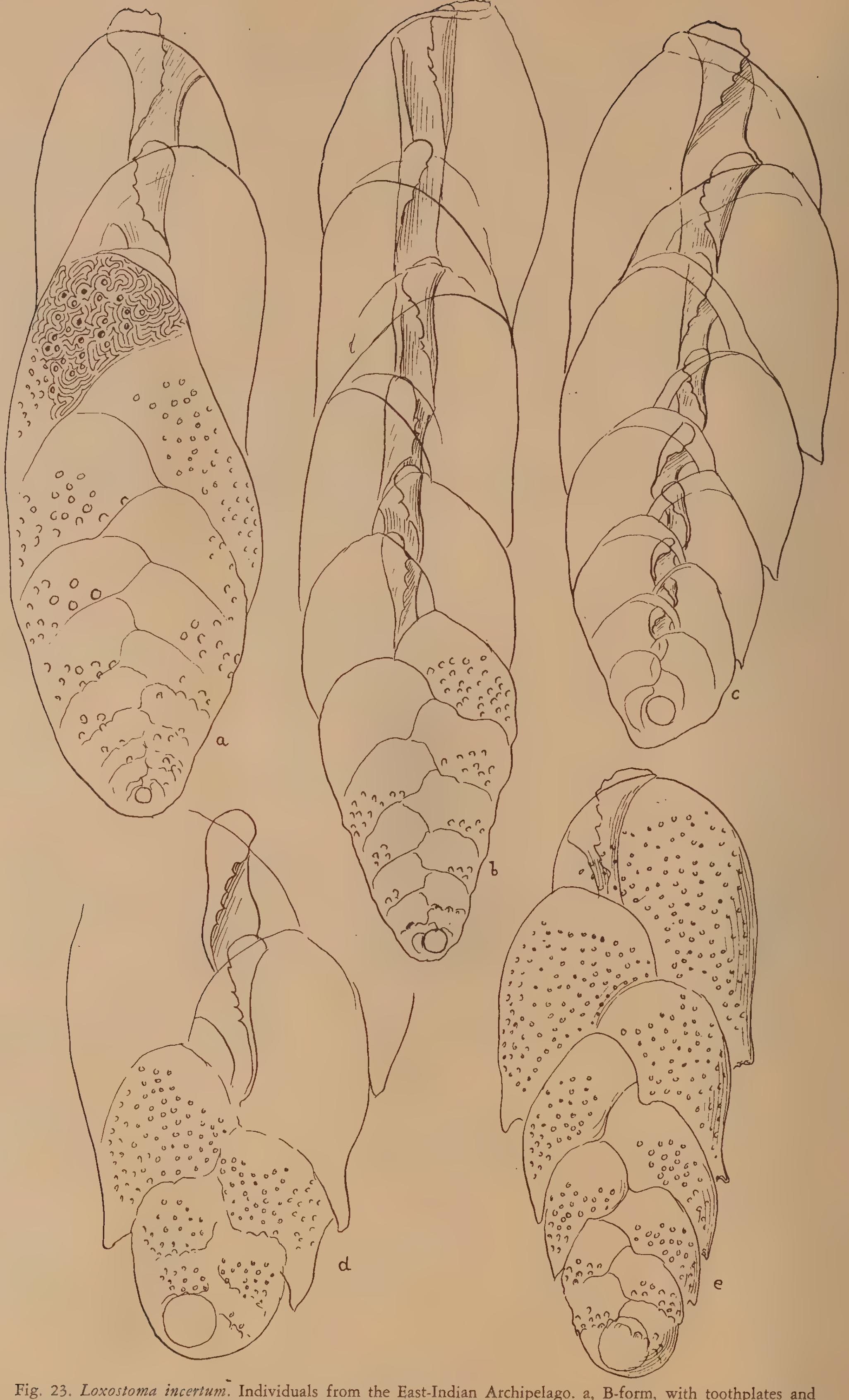


Fig. 23. *Loxostoma incertum*. Individuals from the East-Indian Archipelago. a, B-form, with toothplates and the meandric ornamentation; b, A1 or possibly B-form, with long loxostomine part, with the toothplates; c, A1-specimen, optical section with toothplates; d, initial part of A2-form, with the toothplates; e, total shell of A2-specimen. × 350.

Foram. Res., spec. publ. 9, pl. 22, fig. 10). So there is much controversy in the systematic place of this species.

Many records have been given of recent *Bolivina beyrichi.* So one would be inclined to give the species, found here, the name of *Loxostoma beyrichi,* but for the fact, that Cushman denies the identity of Oligocene *Bolivina beyrichi* with recent specimens. It cannot be identified with *Loxostoma porrectum* either, as I have found, that especially A2-specimens show characters, which do not agree with that species. In this way I was obliged to give a new name to the species; I called it *Loxostoma incertum.*

Description of the species:

Test more or less slender, 3-4 times as long as broad, much compressed. Pores in older chambers somewhat coarser, but in later chambers rather fine, and distinct, always lacking in the apertural part of the chamberwall. This wall shows always a fine meandric ornamentation of the surface, when seen in high magnification. In microspheric specimens the test is not so slender as is the case in A1-specimens, whereas A2-specimens show a much more bolivine test, which always is broader (2-3 times as long as broad). The chamber sutures show a distinct angle at the axis, especially in A2. B- and A1-test are slightly lobulated at the margin, whereas A2-specimens show a distinct spine at the initial (proximal) suture at the margin. Toothplate always loxostomate, with the attached border free in adult chambers, the free folded part with a distinctly sawed border, and an often protruding end, which always is smooth.

Length of tests up to 0,5 mm, breadth up to 0,15 mm.

Bolivina spinescens Cushman
(Fig. 24)

It occurred only in stations south of Sumatra, depth ranging from 377-777 fathoms, and always rare. Only megalospheric specimens are met with. The walls are hyaline, and only few pores are found at the suture directed towards the initial part. Between those pores the suture is excavated, and often forms shorter or larger spines which, however, are very variable. In most cases two rows of pores are found at each suture, the other part of the chamberwall being either totally smooth, or ornamented with longitudinal irregular costae. Often a short spine is found at the initial end of the shell. The aperture is a large, somewhat rounded opening at the suture, without a tooth, and the toothplate is very remarkable for this genus. It consists of a broad plate, which attaches itself at the base of the chamber, running towards the most protruding border of the aperture, while the free part of it is only a somewhat thickened border of the plate, with a very narrow free part. This free part runs equally to the top of the aperture, but it is too narrow to form a visible tooth. A basal hook is seldom formed, as the free tooth is too narrow to form it. Thus we may call the toothplate reduced.

This species was found at numerous stations north of the Archipelago by the Albatross (Cushman, 1942, p. 27) but mostly rarely. Millet found it in the Archipelago itself.

Description of megalospheric form:

Test with blunt or pointed initial end, tapering towards the apertural end, more or less triangular in shape. Margin rounded and very much lobulated. Chambers much inflated, nearly as high as broad, with smooth, very hyaline and thin walls, and only with somewhat coarse pores at the initial suture which, between the pores, forms short bridges, which in most cases near the initial part, but often somewhere else too, become typical spines. Apertural end often with stout spine

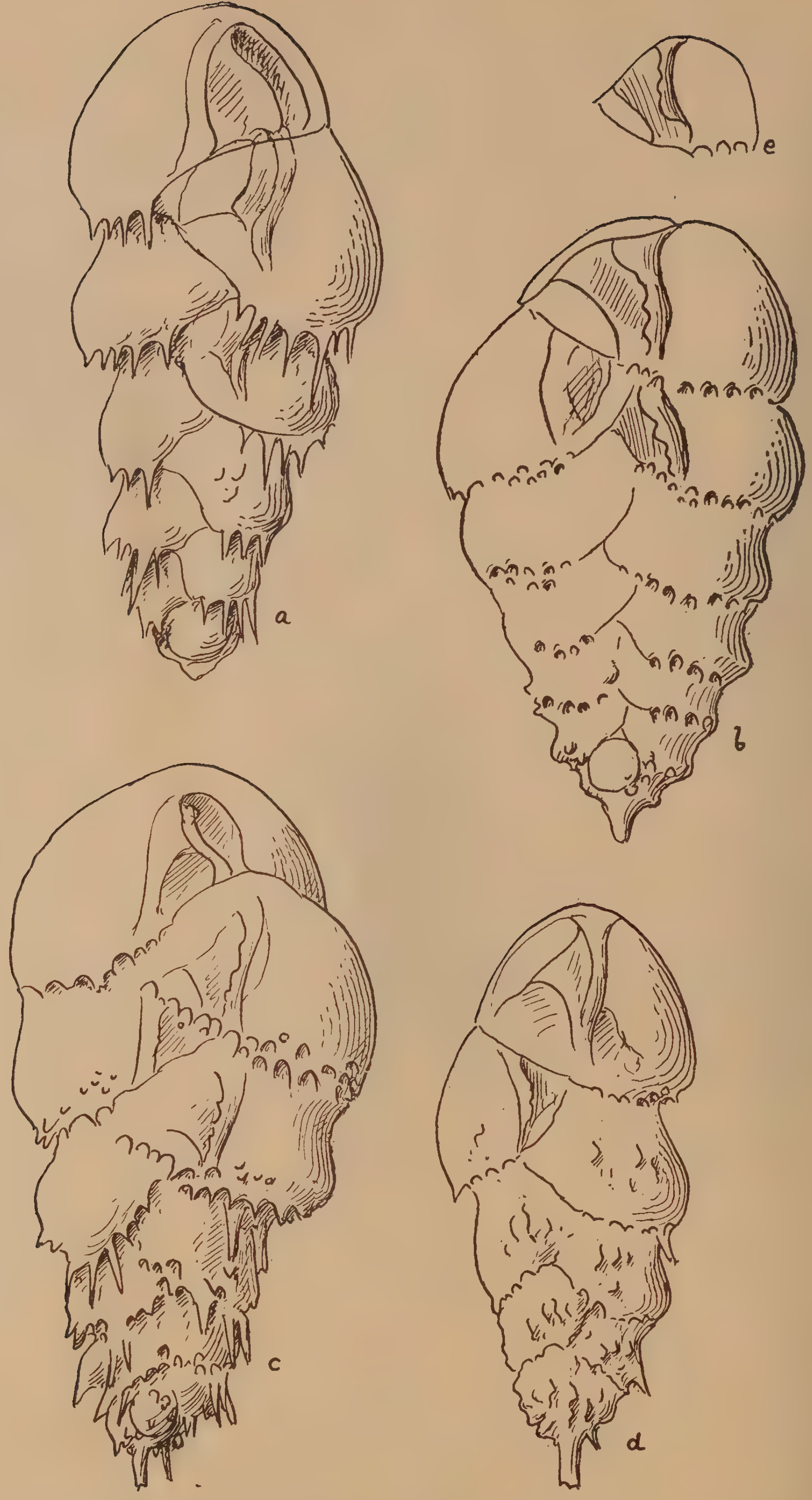


Fig. 24. *Bolivina spinescens* Cushman. a, b, c, d, specimens, showing differences in ornamentation of test; all are megalospheric; e, chamber with toothplate. × 480.

too. Aperture rounded, with very short tooth. Toothplate somewhat reduced, as the free part is very narrow, with lobulated free border.

Length of tests up to 0,23 mm, breadth up to 0,12 mm.

Loxostoma strigosum (Brady)

(Fig. 25)

This species occurred only in gatherings south of Sumatra. According to Cushman it is extremely rare. I found it in nearly 10 specimens, scattered over four stations, depth from 377 to 777 fathoms.

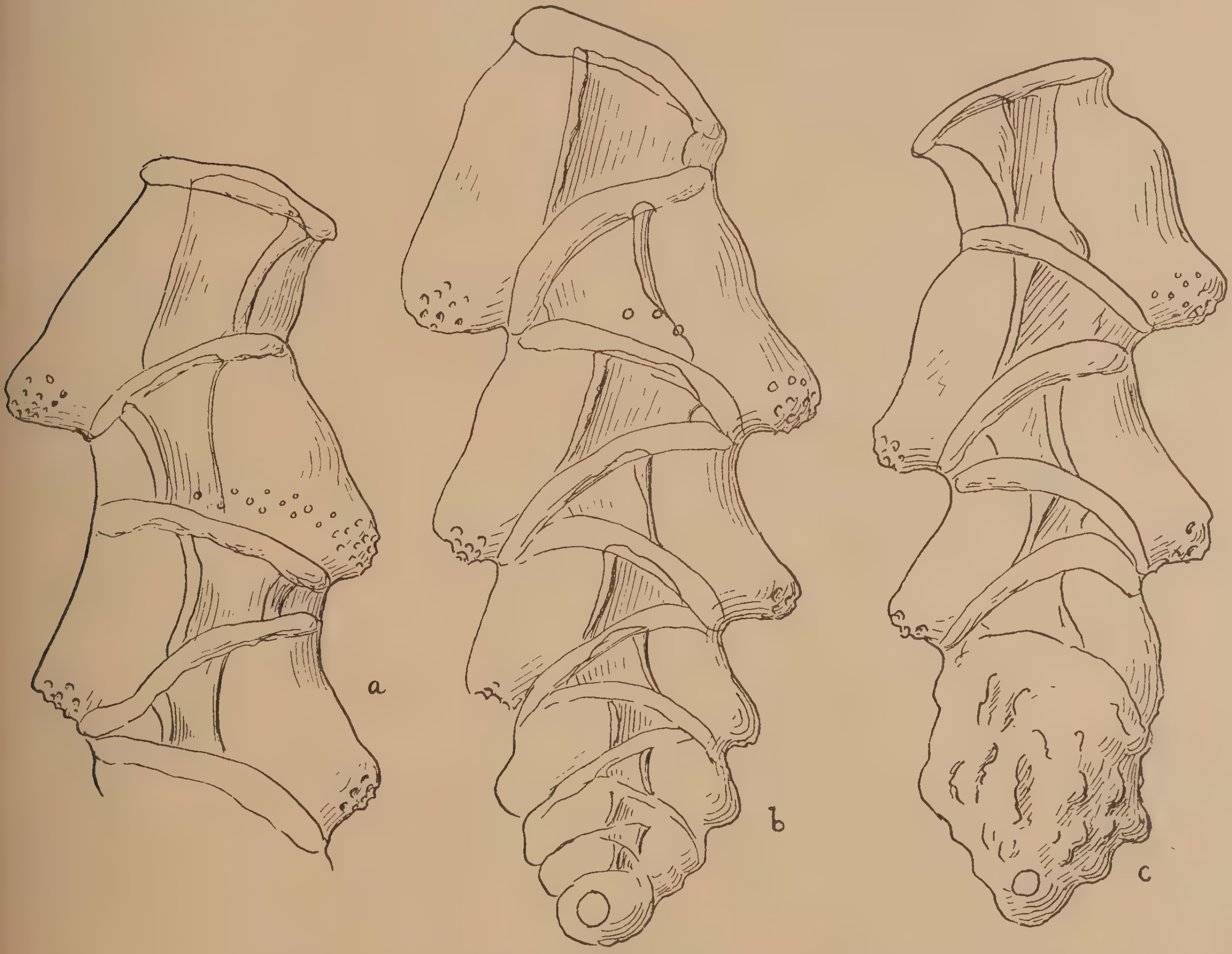


Fig. 25. *Loxostoma strigosum* (Brady). a, broken apertural end of an obviously large specimen, with typical uniserial chambers; b, and c, other specimens; through the hyaline test the toothplates are seen. × 480.

The species must be very closely allied to *Bolivina spinescens,* as here too the walls are very hyaline, the pores are only found near the initial sutures, and here mostly on the protruding points of the chambers, while the toothplate shows the same typical reduction with no real free plate, as was found in the mentioned species. It has been placed in the genus *Loxostoma,* as the younger chambers show the tendency to become uniserial, while the toothplate in these chambers shows the typical structure of that in *Loxostoma.* The whole genus *Loxostoma* however is artificial.

The proloculus always is very small, measuring only 8-10 μ. Most specimens have a length of only 0,30 mm. The walls of the initial part are thickened and often irregularly knobbed and costate.

Heron-Allen had it in his collection from Macassar-Strait, from 45 fathoms. It seems to be a rare species.

Description:

Test elongate, with strongly lobulate margin, as each chamber of the loxostome part forms a protruding sack at its marginal base. Loxostome chambers higher than broad. Walls smooth and very hyaline, having only some pores at the initial border of the protruding sack. Sutures distinct, zig-zagging. Aperture terminal, a narrow elliptical slit, with very poorly developed tooth, surrounded by a raised lip. Biserial part often with short longitudinal costae. Toothplate in biserial part bolivine, with reduced free part, in the uniserial part becoming more or less loxostomine, with both sides free, one of which is somewhat folded into a very narrow free part.

Length 0,30 mm, breadth 0,11 mm.

Rectobolivina bifrons (Brady)

(Figs. 26, 27)

This is a distinct species, though several specimens are nearly round in transverse section. Statistical measurement showed however, that it is different from *Rectobolivina columellaris*. The differences are:

In the microspheric form the number of biserial chambers ranges from 9 to 18. That of the uniserial part from 1 to 10, as in *R. columellaris*.

The A_1-form has a proloculus, which is larger than that in *R. columellaris*. It has a diameter from 31 up to 54 μ. The biserial part of this generation consists of 4-7 chambers, which is the same as in *R. columellaris*. The uniserial part shows 5-11 chambers.

The A_2-form shows a very large proloculus, diameter 73-80 μ, the biserial part consists only of a single chamber, followed by 5 uniserial ones. This form is always a small one, and in some cases two rows of uniserial chambers are found developing from a single proloculus.

The species in some cases is hardly distinguishable otherwise than in the number of the biserial chambers from *R. columellaris*. It may be, that it represents only a variety of it. It was found in the gatherings near Flores, and not south of Sumatra. Some specimens showed a longitudinal striation, which leads to the third species in this group, which was found by me near the Key-Islands. In my paper on this subject I called this third species *R. columellaris* too, or a variety of this species. As the number of biserial chambers in that material in the microspheric form was about 14, I believe, that this striate form is a variety of *R. bifrons* rather than of *R. columellaris*.

The geographic distribution of these three forms, *R. columellaris*, *R. bifrons* and *R. bifrons* var. *striatula* (Cushman) shows, that *R. columellaris* is found in the western part of the Archipelago, south of Sumatra e.g., *R. bifrons* was found near Flores, and not south of Sumatra, while its variety *R. bifrons* var. *striatula* did occur near the Key-Islands, and was in some specimens found in the gathering near Flores. It may be, that circumstances are due to the development of these three varieties, *R. bifrons* then being only a geographic variety of *R. columellaris*.

The inner structure, especially of the toothplate, does not vary in the three so-called species. This is an indication as to the belonging of these three forms to one and the same species, as the toothplate in very closely allied species of other bolivine, uvigerine and buliminine species always shows typical differences, by which the species can be separated. This is not possible in the species *R. columellaris* and *R. bifrons,* and therefore I am inclined to consider them as varieties only, due to environments.

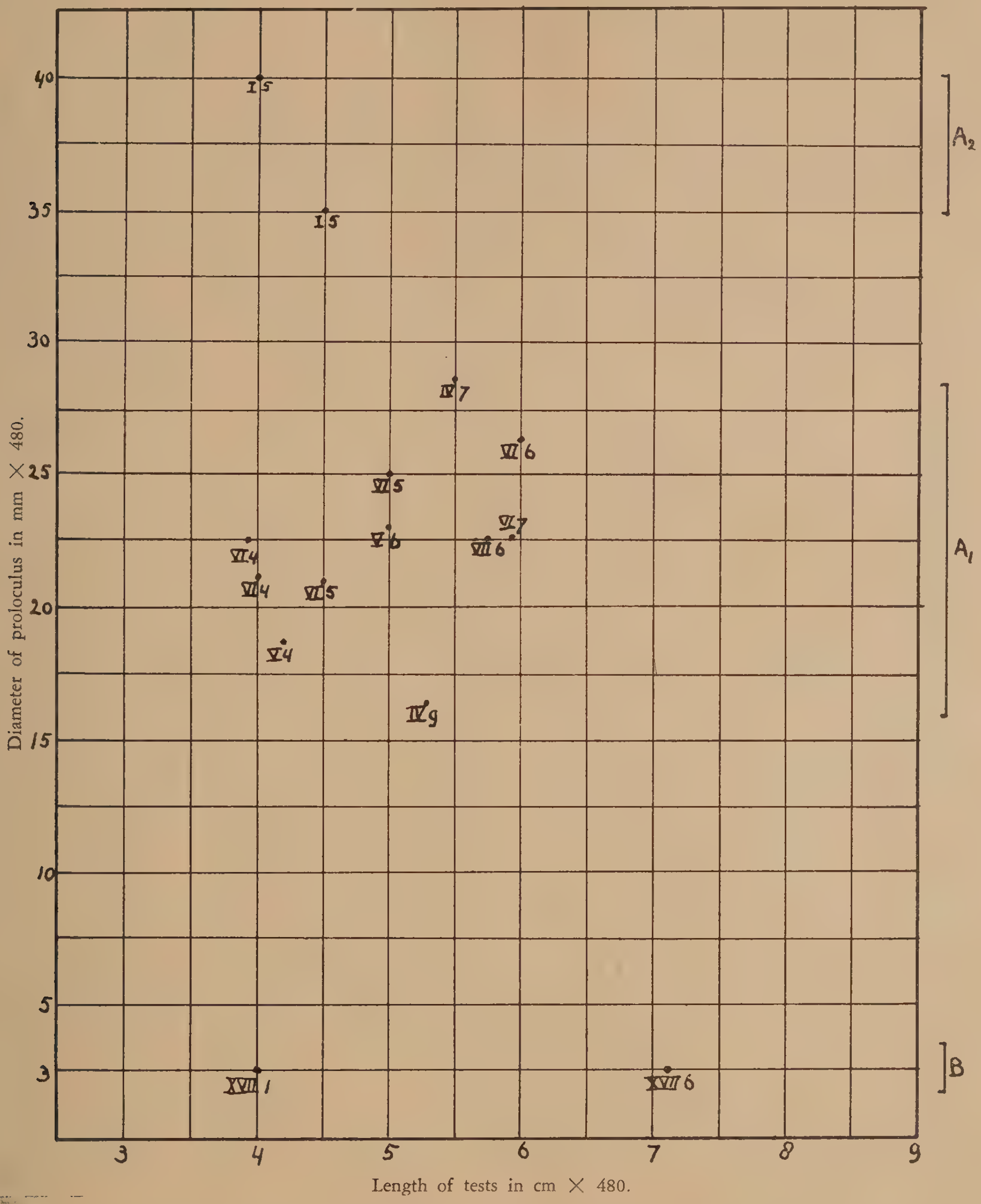


Fig. 26. *Rectobolivina bifrons* (Brady). Diagram, showing relation between length of tests and diameter of proloculus. Figures added: roman. number of biserial chambers, arabic, number of uniserial chambers. All specimens of a single station, 10° 00′ S., 123° 19′ E., depth 453 fathoms.

The variety *striatula* has been found in the stations:

st. 49a 8° 23′ S. 119° 4′ E. depth 69 m
st. 262 5° 53′ S. 132° 48′ E. depth 560 m
st. 310 8° 30′ S. 119° 7′ E. depth 73 m

It has been recorded by Millet as a rare form in the Archipelago. I myself found it also in scattered specimens in the stations.

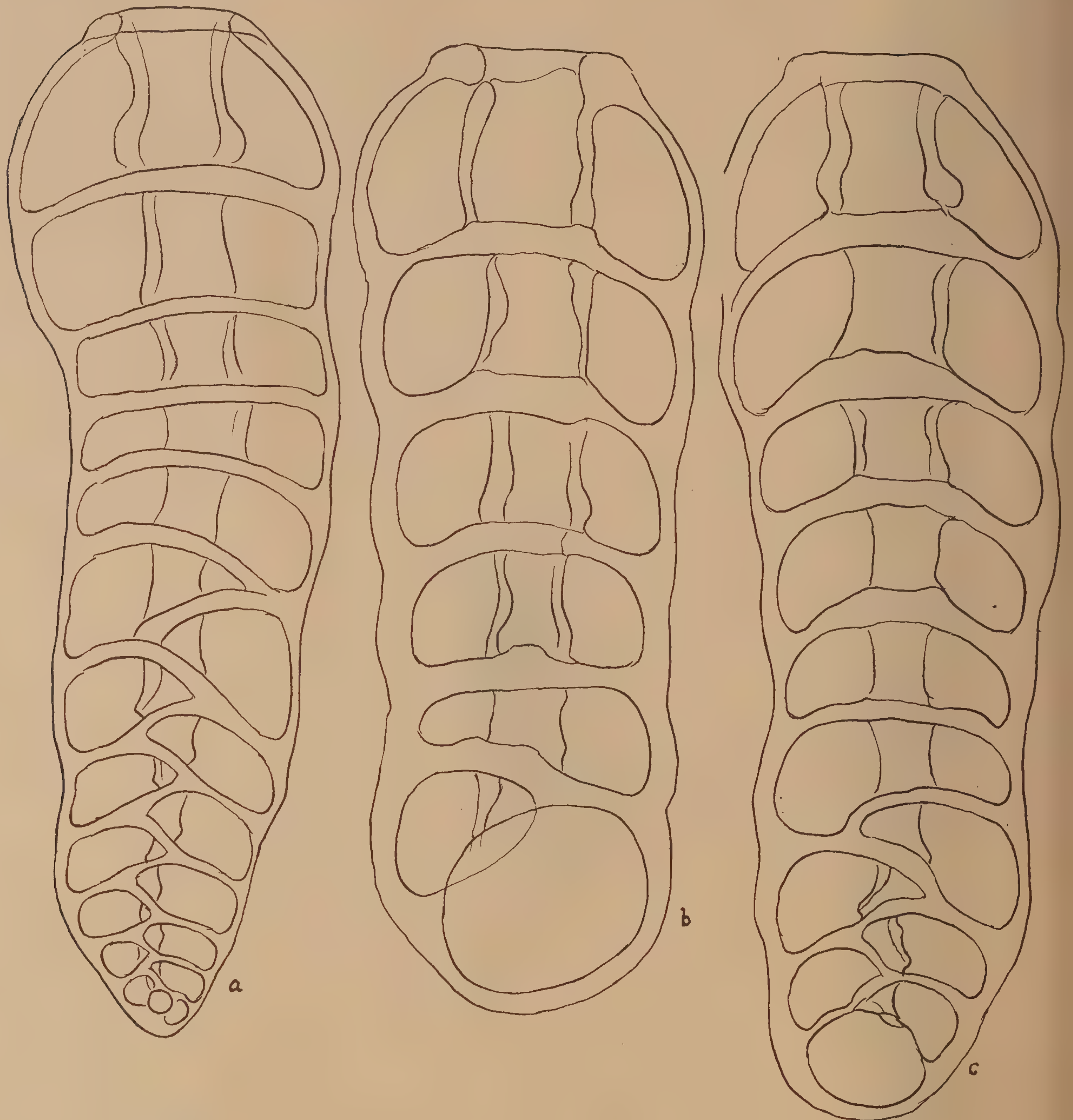


Fig. 27. *Rectobolivina bifrons* (Brady). Optical sections: a, through B-form; b, through A2-form; c, through A1-form. × 480.

Rectobolivina bifrons shows a somewhat compressed test, often with an indistinct depression along one of its sides. This feature, together with the large number of biserial chambers, especially in the microspheric form, indicates, that the species is somewhat more allied to *Bolivina,* than its other allies, *R. striatula, R. columellaris* and *R. raphanus.* The fine pores of all these species however, indicate, that they must be allied which each other, and the hyaline walls together with the thickened initial walls point to forms such as *Bolivina seminuda.*

Sagrina tessellata Brady
(Fig. 28-31)

In 1884 (Challenger Report, p. 585, pl. 76, figs. 17-19) Brady described, from very pocr material, a new species, which he described as *Sagrina tessellata.* Next to it he created another one, *S. limbata.* Both species seemed to be very rare, and there was later much doubt as to it being a real Foraminifer. In the year 1903 Millet (Journ. Royal Micr. Soc., p. 273-274, pl. 5, figs. 16-19) described from the Malayan Archipelago another set of few specimens of these wonderful species, but he too failed to analyse the tests otherwise than giving some not very accurate drawings from outer characters. I found a single specimen at St. 226, 5° 26′ S., 127° 36′ E., depth 1595 m. It has been analysed throughout, and I now am able to give a full description of the real structure of the test.

The specimen is curved, as in all drawings hitherto known, and consists of four partitions, separated by slight but distinct sutures. The first partition consists of a small proloculus, with a diameter of 13 μ. Next to it is situated a chamber of about the same size, and then two other chambers are found, situated on a somewhat higher plan, obviously two biserial chambers. Then follows a chamber, forming the whole next part of this first partition. The uniserial chamber is closed by a thin horizontal plate, only pierced by fine pores. This chamber shows at its outer wall a row of nearly square windows, in which the very fine pores of the side-wall are situated.

The second, third and fourth partitions of the test each show outerly horizontal rows of windows, pierced by the same fine pores. But there exsists a difference as to the inner structure of those partitions, in respect to the first one. Each partition ends with a rounded aperture with a narrow opening and a short neck, while each partition is divided by three or four horizontal thin lamellae; when seen from the curved side in each partition a single chamberlet is seen, while, when seen from the side, in which the test seems straight, two divisions are seen in optical section. In transverse section the windows show to be constructed by a folding of the wall, each folding forming a short septum protruding into the inner lumen of the chamberlet, while at that side, in which one sees in optical section two divisions, this folding runs far more deeper into the chamberlet, as to form a real septum; this runs toward the middle of each chamberlet, while here the two bordering windows are larger, and the whole section of the wall here shows a longitudinal furrow, just as is found in many specimens of *Rectobolivina bifrons.* I am convinced, that in megalospheric forms of the species this furrow is much more strongly accentuated, especially in the A_2-form, as in *Rectobolivina bifrons.* This points to the characters, described for *Sagrina limbata,* in which both mentioned authors give in their figures a very large proloculus; in *Rectobolivina bifrons* this A_2-proloculus is also a very large one.

Now we may direct our attention to the larger septum in each chamberlet. This septum begins at the apertural neck of the whole division. Here it shows in all characters the shape of a toothplate, and when it reaches the next foramen of the division, it runs up to it and into it, as is the case in real *Rectobolivina* also. So I am certain, that this septum is nothing but a septum, resembling those between the windows, but enlarged by the attached toothplate. In *Rectobolivina* the toothplate is free from the furrow, but at its base, where it is attached to the aperture, in *Rectobolivina bifrons* it is also attached to the wall at the furrow, as the aperture itself in this species is situated close to that furrow. This indicates, that *Sagrina tessellata* is nothing but a more developed species, allied with *Rectobolivina bifrons.* A comparison of the figures, given here from transverse sections of *R. bifrons* as well as of *S. tessellata* will prove this suggestion.

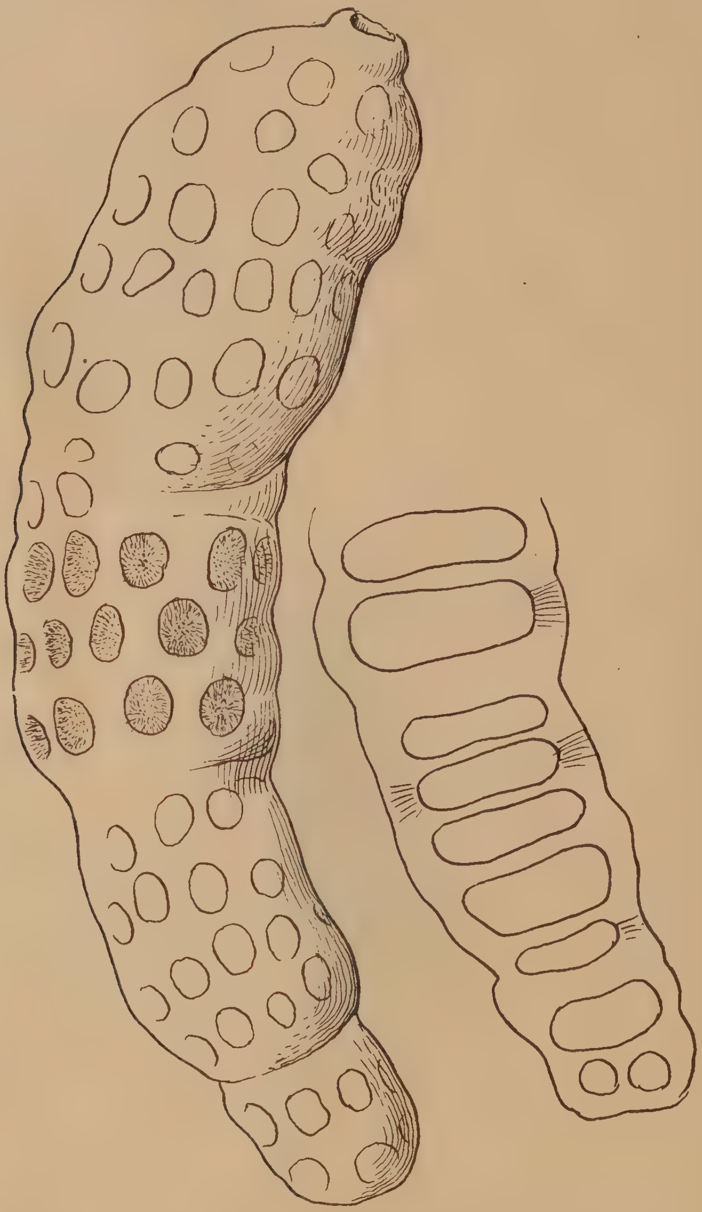


Fig. 28. *Sagrina tessellata.* Test from aside, together with optical section, showing the chambers, as they are figured by Brady and Millet for *S. tessellata.* × 480.

Now we have to consider the transverse septa as well. These septa, dividing each partition into four, or five chambers, is very thin, except for the part near the outer wall, where it becomes at once thicker. This leads to the conclusion, that at this outer wall likewise a folding of the wall toward the inner chamber has taken place, thus forming this thickening. The transverse septum itself seems to derive from the toothplate, as the plate at its septum shows a thickened part too, sustaining the septum and intervowen with it. Such outgrowths of toothplates are not uncommon in the whole group of toothplate-Foraminifera, as they are likewise found in the group of the *Uvigerinidae,* where the toothplate forms the so-called wing, in some species.

We now are able to describe the test of our species more fully.

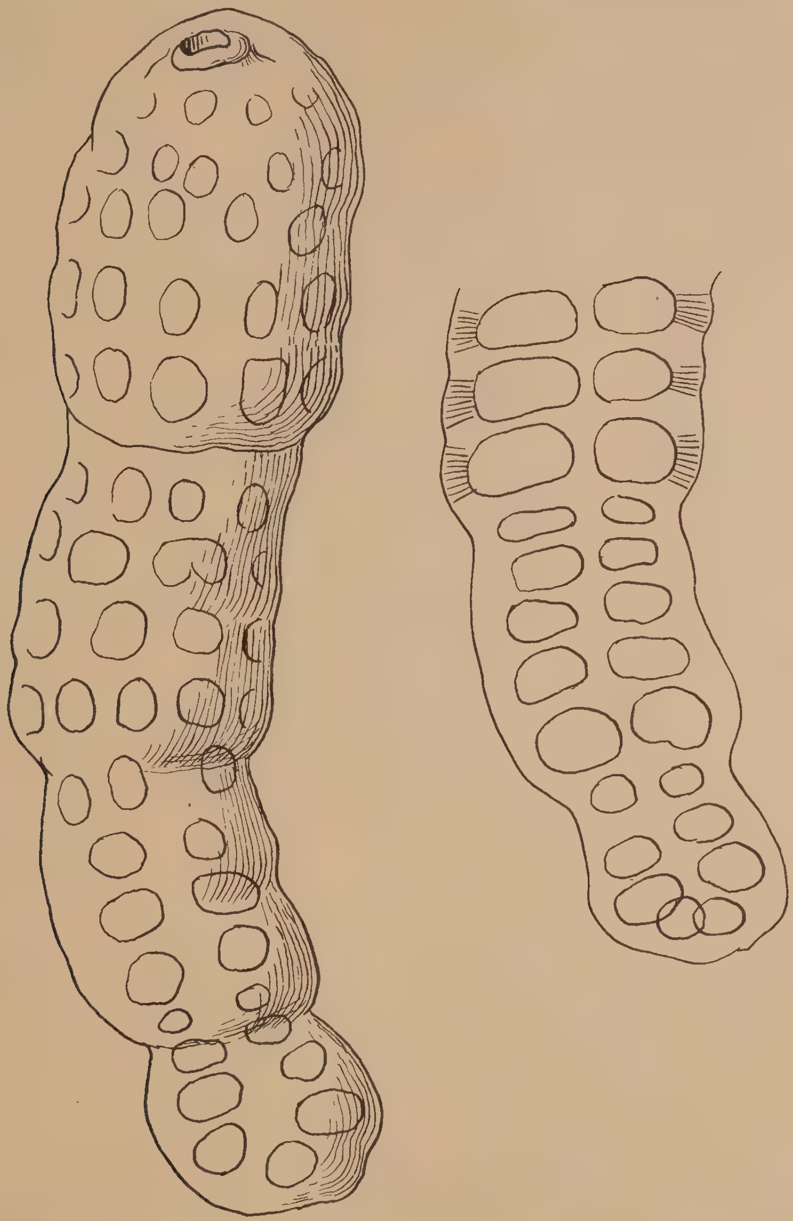


Fig. 29. *Sagrina tessellata.* Test from the foreside, with optical section, showing the chambers, as they are figured by Brady and Millet for *S. limbata.* × 480.

Description of *Sagrina tessellata.*

The rectobolivine species, closely allied to *Rectobolivina bifrons,* shows a test, in the A_1-form beginning with a short set of biserial chambers, in the A_2-form with a single large proloculus. Then 2-5 chambers are added, each ending with a central, rounded aperture with very short neck and not well-developed phyaline lip. Each chamber is divided into 2-5 chamberlets by transverse septa, which septa are thin and derive from an outgrowth of the toothplate. Each toothplate runs straight along the whole chamber, transversing each of the septa; it is attached to a distinct furrow, running along one side of the whole chamber. The chamberwalls are folded toward the chamber-lumen, as to form longitudinal ridges protruding into the chambers, and connected with transverse foldings, forming

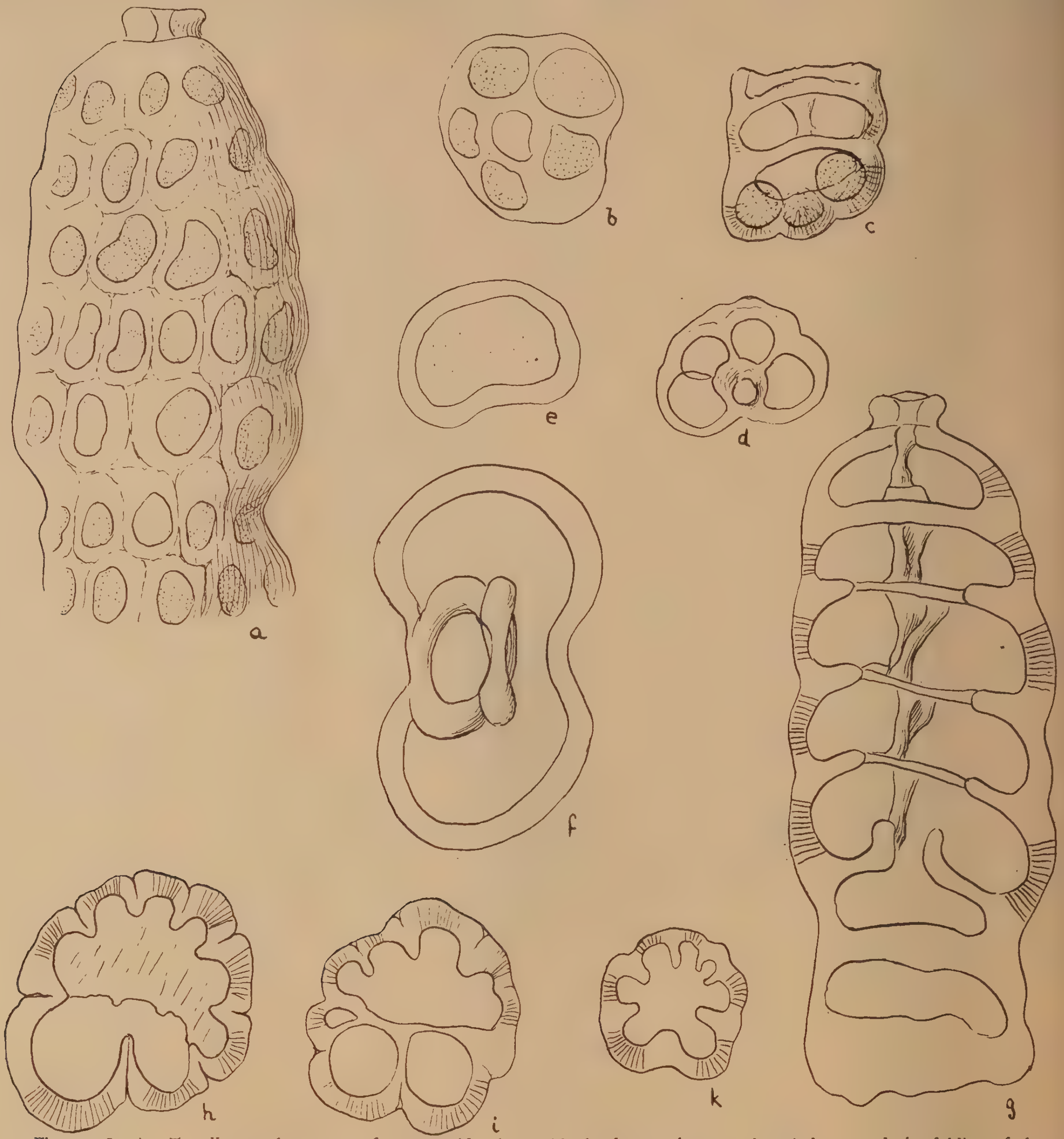


Fig. 30. *Sagrina Tessellata.* a, latest part of test, outside view, with the furrows between the windows, made by folding of the wall, and the very fine pores, × 630; b, initial part, seen from below, with proloculus without pores, × 630; c. same part, optical section; d, section through initial part; e, section through first uniserial chamber, with its lamellum, pierced by scattered fine pores d, and e, × 630; f, transverse section through a chamber of *Rectobolivina bifrons,* with aperture and toothplate, for comparison, × 480; g, longitudinal section through latest part of *Sagrina,* × 480; h-k, successive sections through middle part of test, showing the folding of walls and the two larger partitions at the foreside, × 630.

the outer part of the transverse thin septa. These foldings thus form between them more or less regularly placed windows, in which the very fine pores of the chamberwalls are found. As in *R. bifrons,* in the A₂-form, hitherto known as *S. limbata,* the longitudinal furrow, connected with the toothplate, is much more pronounced than in the A₁-form, and consequently ones attention is drawn to the division, formed by this furrow, together with the toothplate, dividing each chamberlet nearly wholly into two longitudinal parts, as indicated by the figures, given by several authors.

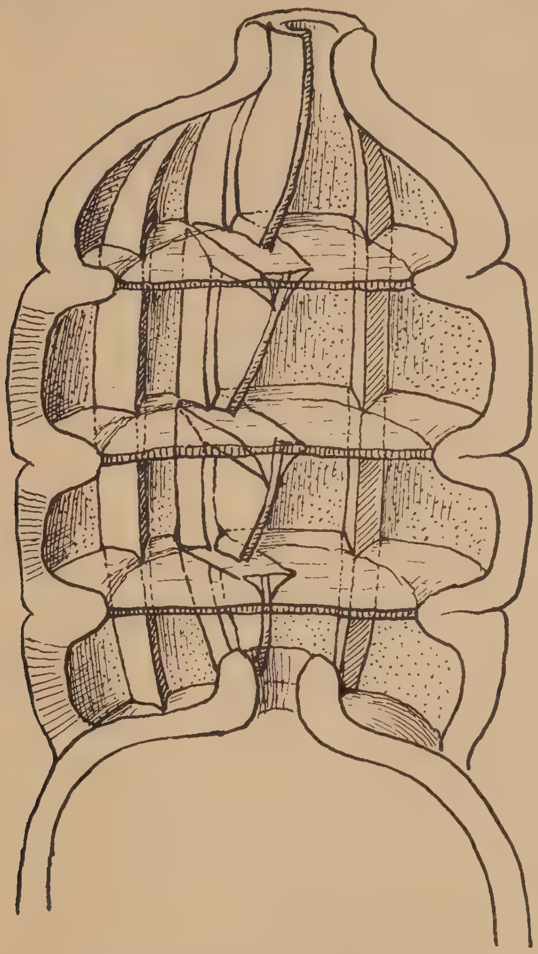


Fig. 31. *Sagrina tessellata.* Schematic figure of structure of test. The test is imagined in longitudinal section, fore part removed; the large septum with the toothplate is imagined behind, so that the two bordering larger partitions together with two side-partitions are seen from within.

The B-form is hitherto unknown, as the species is a very rare one. It has been found at several localities in the tropical Pacific, but always only in one or very few specimens, so that up to now only less than 10 specimens are known.

The old name *Sagrina,* first mentioned by d'Orbigny, emended by Parker and Jones, was given to many species, belonging, as is known now, to very different genera. Some of them belong to *Rectobolivina,* others to *Siphogenerina.* So we may preserve this classic name for those species, in which the chambers are divided into chamberlets by transverse septa, as is found in the single species, known to exist, *Sagrina tessellata.* It is probable, that the third species, belonging to those, described as *Sagrina, S. annulata,* does not belong to this group.

Rectobolivina columellaris (Brady)

(Figs. 32-35)

Recorded from different stations in the Indo-Pacific was *Sagrina columellaris* Brady (Challenger, Vol. 9, 1884, p. 581, pl. 75, figs. 15-17). Other authors believed it to belong to the genus *Siphogenerina* (Cushman, Bull. 71, Nat. Mus., pt. 3, 1913, p. 104-105, pl. 47, figs. 2, 3). Cushman found it at several stations in the Philippines, but always rare (Nat. Mus. Bull. 100, 1921, p. 276-277, pl. 56. fig. 1).

I found it in some abundance in a station at 377 fathoms depth, 2° 17′ S., 99° 27′ E. It occurred too in several specimens in station 2° 56′ S., 99° 58′ E. In the latter station several specimens showed strong longitudinal costae along the surface of the older parts of the shell, as is the case in *S. raphanus,* but they never showed the phyaline neck of the latter species. Those ornamented specimens showed all to be microspheric, while megalospheric specimens of the same locality were smooth.

The species was moreover found in the following stations:

St. 154; 0° 7′ N., 130° 25′ E., depth 83 m.
St. 204; 4° 20′ S., 122° 58′ E., depth 75-94 m.
St. 226; 5° 26′ S., 127° 36′ E., depth 1595 m.
St. 251; 5° 28′ S., 132° 0′ E., depth 204 m.
St. 260; 5° 36′ S., 132° 55′ E., depth 90 m.
St. 262; 5° 33′ S., 132° 48′ E., depth 560 m.

I studied the species statistically, and it was found, that three distinct groups can be distinguished, when the diameter of the proloculus is considered in respect to the total length of the shell.

Forma B. Shells long, from 0,63 up to 0.94 mm length, stoutly built with thick walls, especially in the initial part. This part shows a somewhat pointed end. Sutures of the chambers indistinct, chambers not inflated, in some cases the wall ornamented with flat longitudinal ridges. Biserial part of the shell somewhat broader than the first uniserial chamber, shell very gradually broadening. Proloculus about 8 μ diameter, followed by 8 or 9 biserial chambers. Uniserial part consisting of 8-10 chambers.

Forma A_1. Length of total shell from 0,44 up to 0,75 mm. Initial end bluntly rounded, with very thick walls. First uniserial chamber as broad as the initial part, shell gradually increasing in breadth, but the lastformed chambers slightly smaller. Biserial part of about 5-8 chambers following a proloculus with diameter from 13 up to 30 μ; number of uniserial chambers from 4 up to 9.

Forma A_2. Initial part very bluntly rounded, somewhat broader than the first uniserial chambers, and consisting of a proloculus with diameter from 40 up to 48 μ, followed by a biserial part of 2 to 5 chambers, mostly 2. The uniserial chambers are more inflated than in the two other generations, their number ranging from 3 up to 9. Total length of this form from 0,44 up to 0,75 mm, most specimens somewhat smaller than in forma A_1.

I studied very accurately the inner structure, as in the genus *Siphogenerina* the initial part must be triserial. But in all cases I found, that the arrangement was a biserial one, as in *Bolivina.* Therefore the species does not belong to *Siphogenerina,* but to *Rectobolivina.* This was in agreement with another peculiar feature of *Bolivina,* the occurrence of the toothplate with its tooth.

In the biserial part this plate shows the typical habitus of that of *Bolivina.* As I described it already, when dealing with the latter genus, I found, that in *Bolivina,* and now also in the biserial part of *Rectobolivina,* this plate is fastened at one side of the aperture of the former chamber, and is erected in such a way, that, by contorting itself, it is attached to the opposite side of the aperture of the chamber itself, giving rise to a tooth by means of its folded and flaring side. Thus, in *Bolivina* too, when seen from the flat side of the shell, it looks like a sipho which it is not, and cannot be, for in that case it would exclude the volume of the chamber from its proper mouth!

In the uniserial part of *Rectobolivina,* when seen in such a way, that the biserial part of the shell is seen as in *Bolivina,* the plate looks as a sipho, and it has been described as such. But

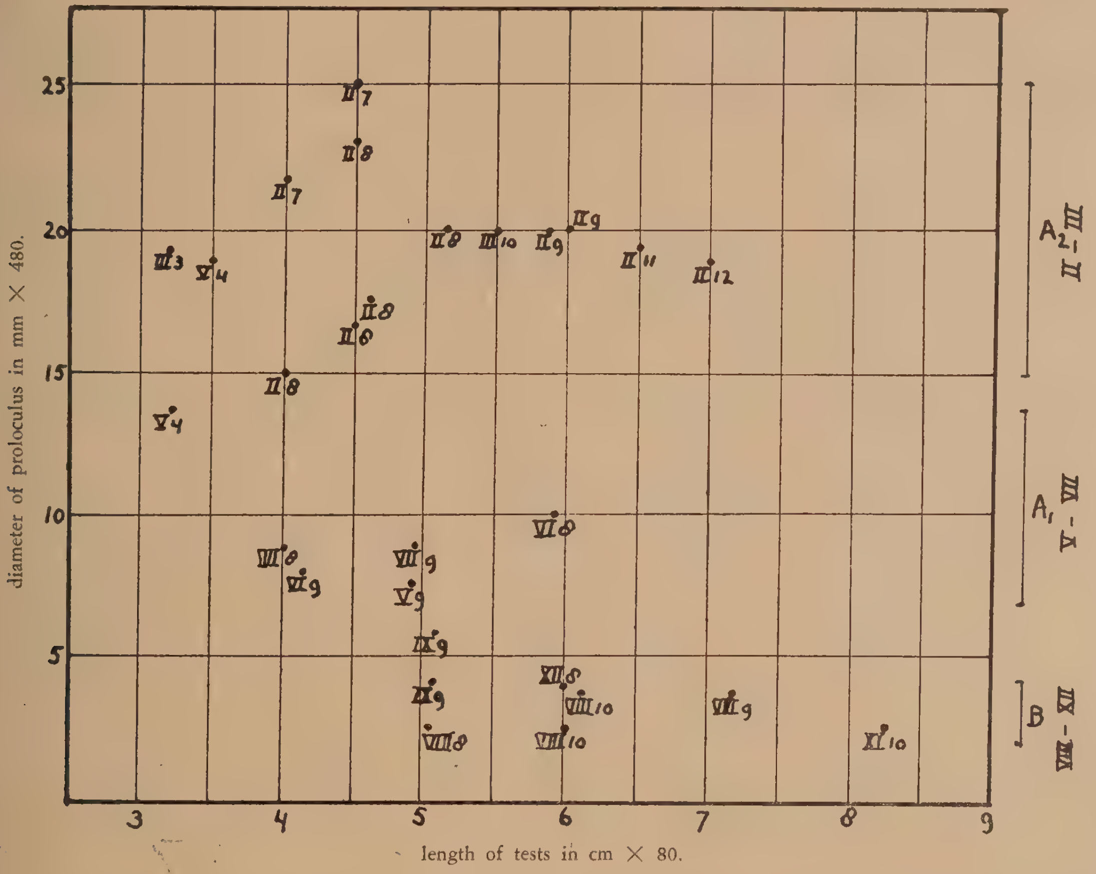


Fig. 32. *Rectobolivina columellaris* (Brady). Diagram showing relation between length of test and size of proloculus. Added are the number of biserial chambers (roman figures) and that of the uniserial chambers (arabic figures). The three generations cannot be separated by the diagram only, but three distinct groups are found, when the number of chambers is taken in consideration.

when seen from the side, so that the biserial part is seen so that the chambers of it lie in a single plane, one observes, that this sipho is a very flat one, without an inner hole! And here too, the contorted plate is arranged in such a way, that the flaring part of it is found at the opposite side of the mouth of the chamber, considered in respect to the side of the former aperture, from which it originates. It never reaches the side of the next aperture, but remains totally free and forms the tooth of that aperture. This situation is clearly shown in transverse section in succession.

Once more it is shown, that the apertural plate is a very conspicuous and constant characteristic of all genera, allied with *Bolivina,* and must be regarded as a characteristic of very large value.

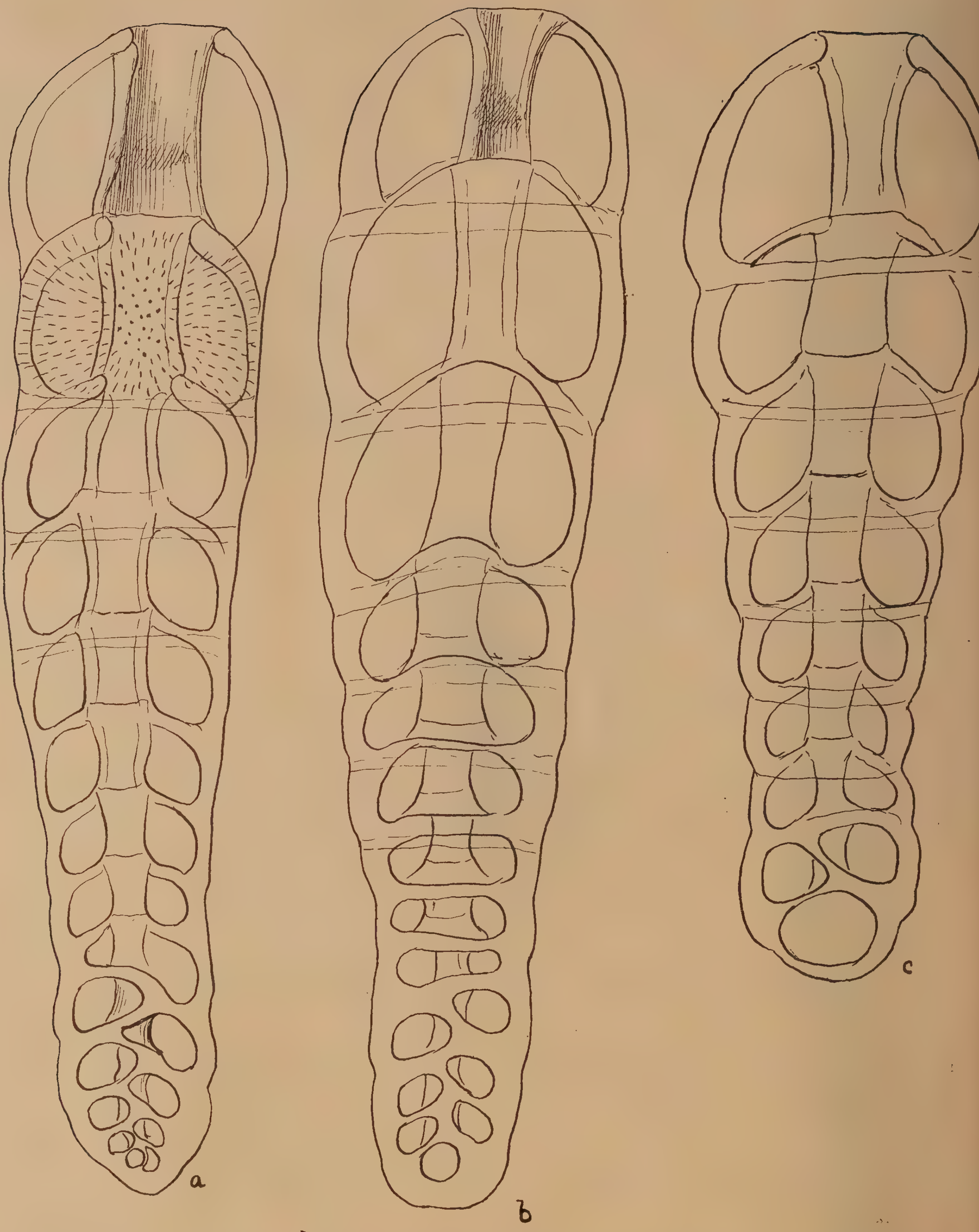


Fig. 33. *Rectobolivina columellaris* (Brady). a, optical section through B-form, showing pores of one of the chambers and tooth-plates; b, optical section through A_1; c, optical section through A_2. × 480.

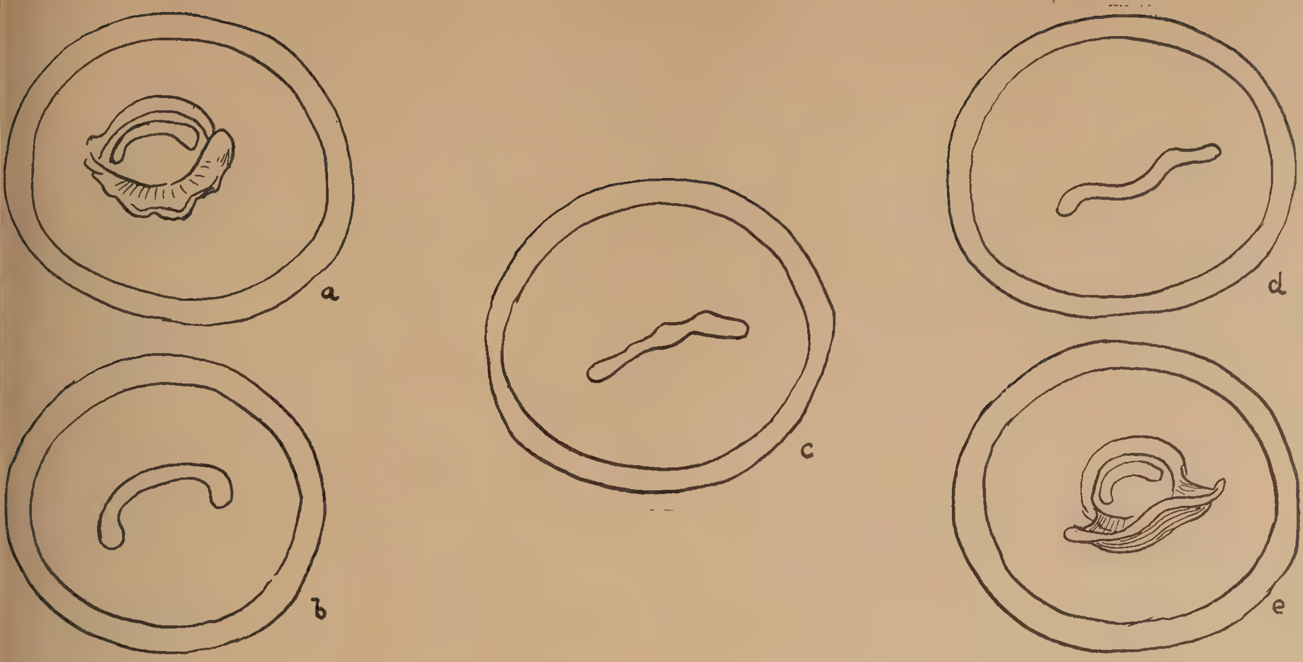


Fig. 34. *Rectobolivina columellaris* (Brady). Successive sections through one chamber. a, view on the upper wall of the chamber, with base of next toothplate and upper end of the toothplate of the chamber sectioned; b, c, d, successive sections of the chamber itself; e, view on the lower wall of the chamber, showing base of toothplate and toothplate-end of next chamber. × 400.

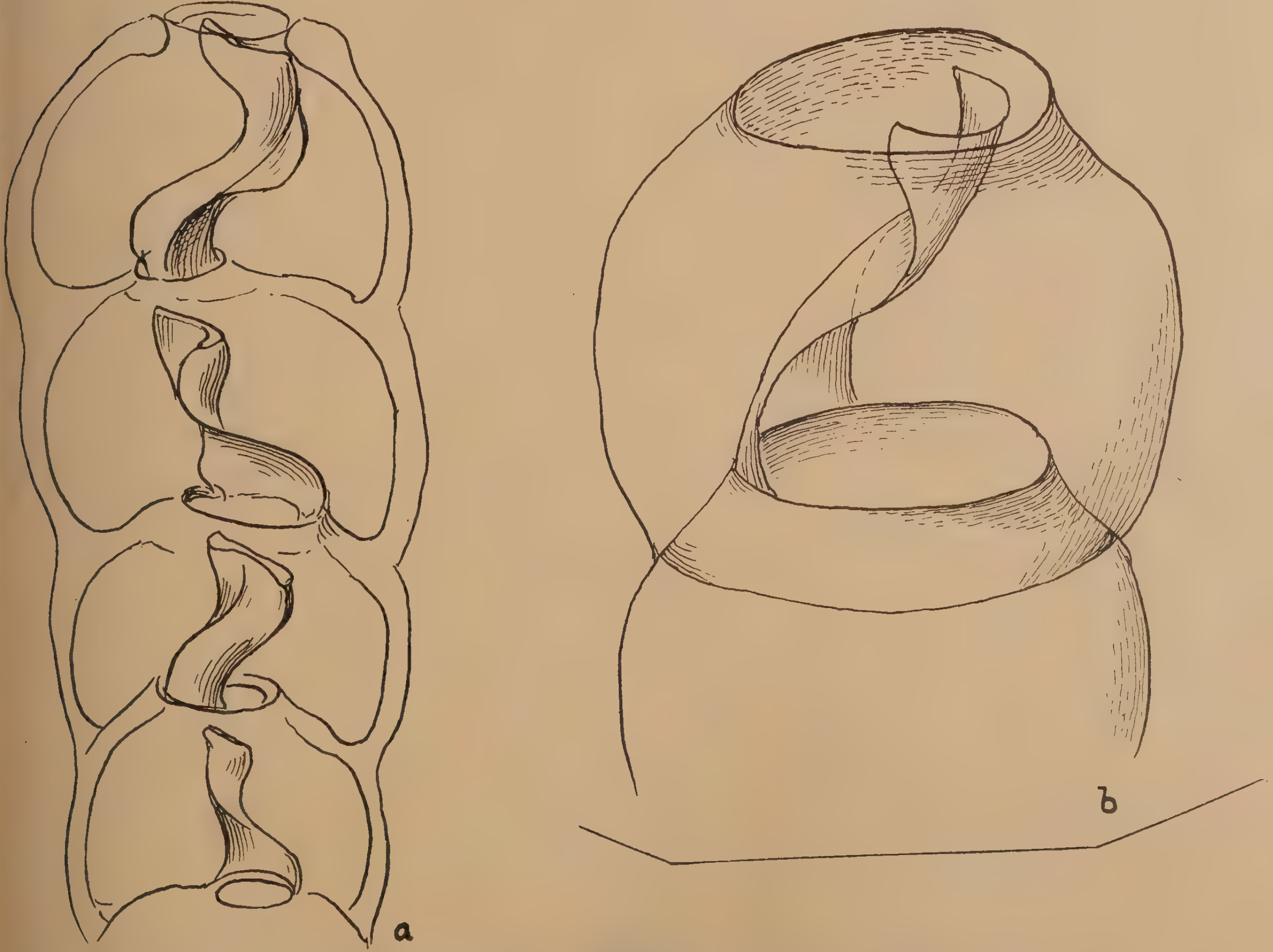


Fig. 35. *Rectobolivina columellaris* (Brady). a, optical section, from aside (biserial chambers in plan of vision), showing situation of toothplates; b, schematic drawing of toothplate. a, × 480.

Loxostoma karrerianum (Brady)

(Figs. 36-38)

This typical Pacific species occurred in some abundance in a gathering by the steamer "De Telegraaf", at 8° 15′ S., 118° 56′ E., at a depth of 340 fathoms, and in single specimens in gatherings in the neighbourhood. 46 specimens were found, from which 7 showed to be microspheric, and 13 of the A_1-generation, the remainder were A_2.

5 spec.	8° 11′ S.	118° 43′ E.,	1015 fathoms
11 spec.	10° S.	123° 19′ E.,	453 fathoms
Some specimens at St.	2° 6′ S.,	99° 54′ E.,	778 fathoms.

The species furthermore has been recorded by Millet (1900) from the Malay Archipelago, from Great Barrier Reef, from Darvel Bay, Borneo, South of Buru and from Makassar Strait. It has been recorded by Cushman from off Java.

B-form. This long and slender form, with comparatively narrow strigulations along the walls, has a proloculus with diameter 6 μ. 4 specimens had 13, 15, and two of them 17 chambers following the proloculus. Length from 0,32 up to 0,46 mm, breadth from 0,10 up to 0,14 mm, the breadth of the two other generations also. But, as the B-form is longer than the other two, its total shape is more slender. The mouth in all forms is an oval opening with very short neck and somewhat phyaline lip. The individuals of the B-form possess no spine at the initial end, but very short spines, representing the thickened costae, cover the initial part.

A_1-generation. 13 individuals were found, with diameter of proloculus of 10-17 μ, followed by 11 chambers. The total form is broader than that of the B-generation, the costae are as thin. Length of total shell 0,24-0,40 mm, breadth 0,10-0,14 mm.

A_2-generation. The total form of the shell is more robust, diameter of proloculus being 17-27 μ. The length ranges from 0,18 up to 0,70 mm, the breadth is the same as in both other generations.

The costae in this generations are somewhat fewer than in B, and at the initial end they melt together in the shape of spinous protuberances. The shells mostly possess a large and stout hyaline spine at the initial end.

Transverse sections showed, that the inner walls of the chambers are smooth, and from each phyaline lip of an aperture of the chambers a toothplate runs upwards towards the next mouth. This toothplate is always attached at the inner wall of the chamber, at which wall the aperture of the former chamber opens too. As this toothplate runs nearly straightway from this inner side towards the centre of the chamber, it is attached at its base to one of the sides, parallel to the broader side of the shell, and always alternating with the side of the former and next aperture. This situation of the toothplate indicates, that *Loxostoma* is nearly equally built as *Bolivina,* but in *Bolivina* the toothplate always is folded double, to form its typical tooth. Here the toothplate is straight, and it never reaches the neck of the aperture.

In all specimens the aperture never reaches the base of the chamber, but it becomes never terminal. This, and the somewhat reduced shape of the toothplate, which is moreover very thin, are the main characteristics, by which the genus *Loxostoma* may be distinguished from *Bolivina.* Of those two characteristics, that of the toothplate is the most convincing.

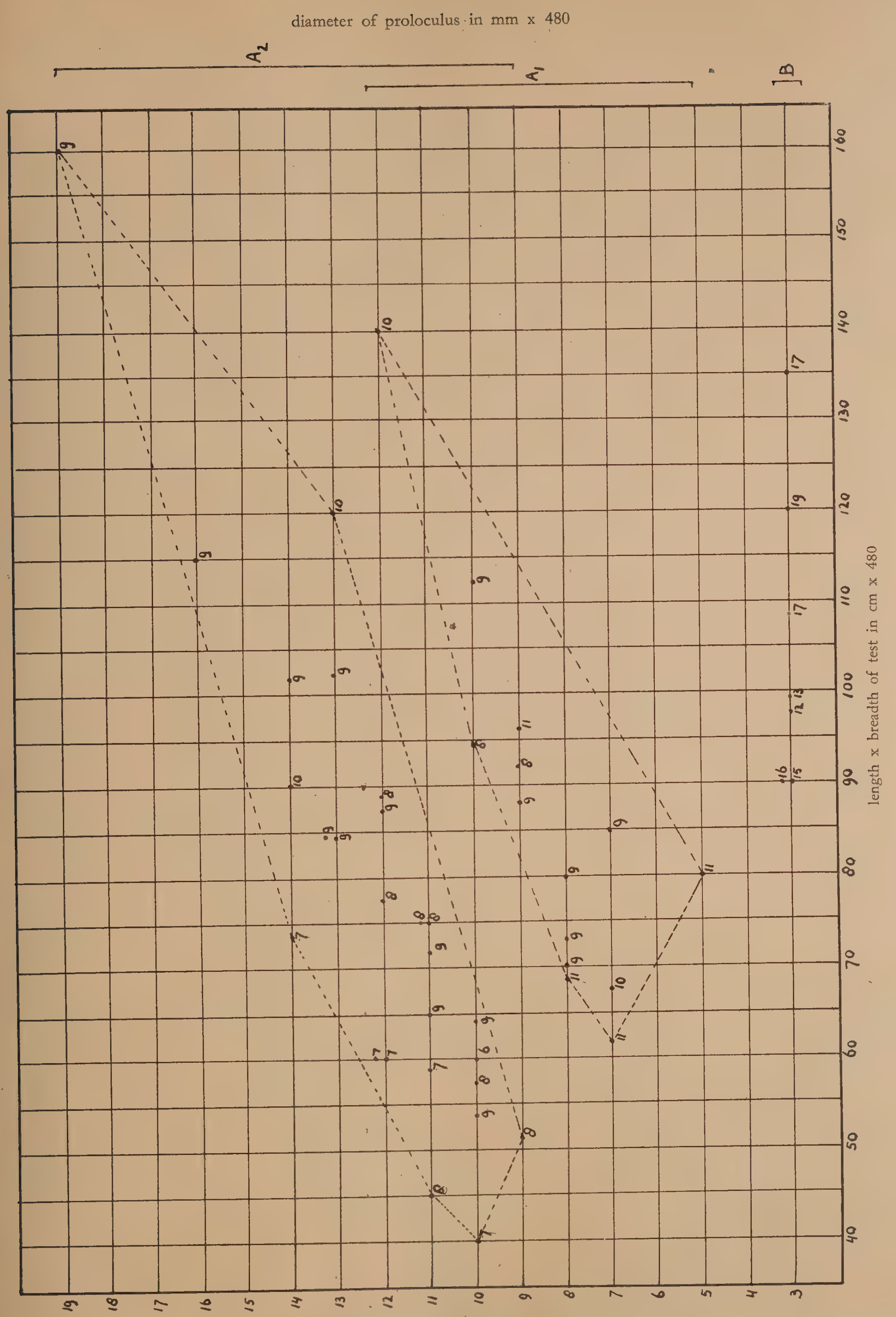


Fig. 36. *Loxostoma karrerianum* (Brady). Diagram showing relation between product of length and breadth of the whole shell and the size of the proloculus. The A-forms are somewhat overlapping and show, as in most bolivine species, the tendency to become larger with the increase of the size of the proloculus.

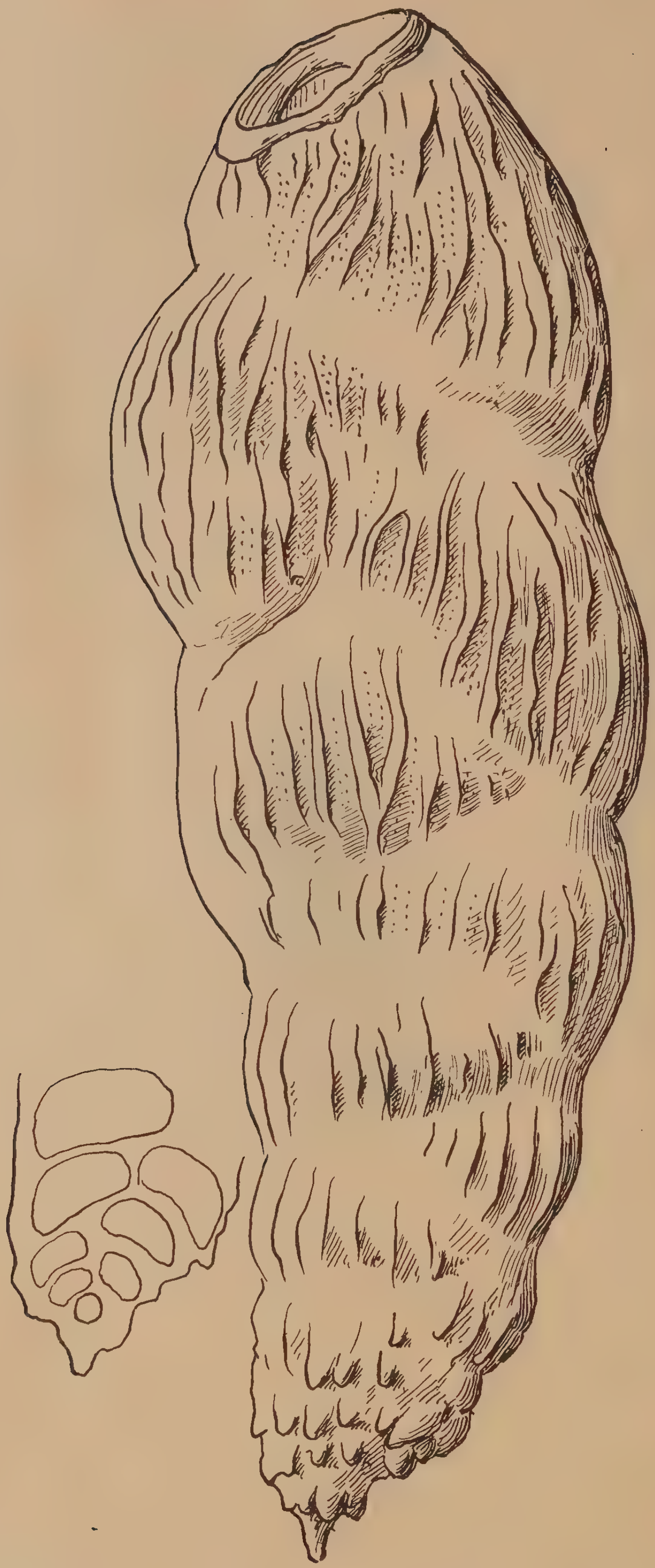


Fig. 37. *Loxostoma karrerianum* (Brady). Microspheric specimen, with section through initial part. × 480.

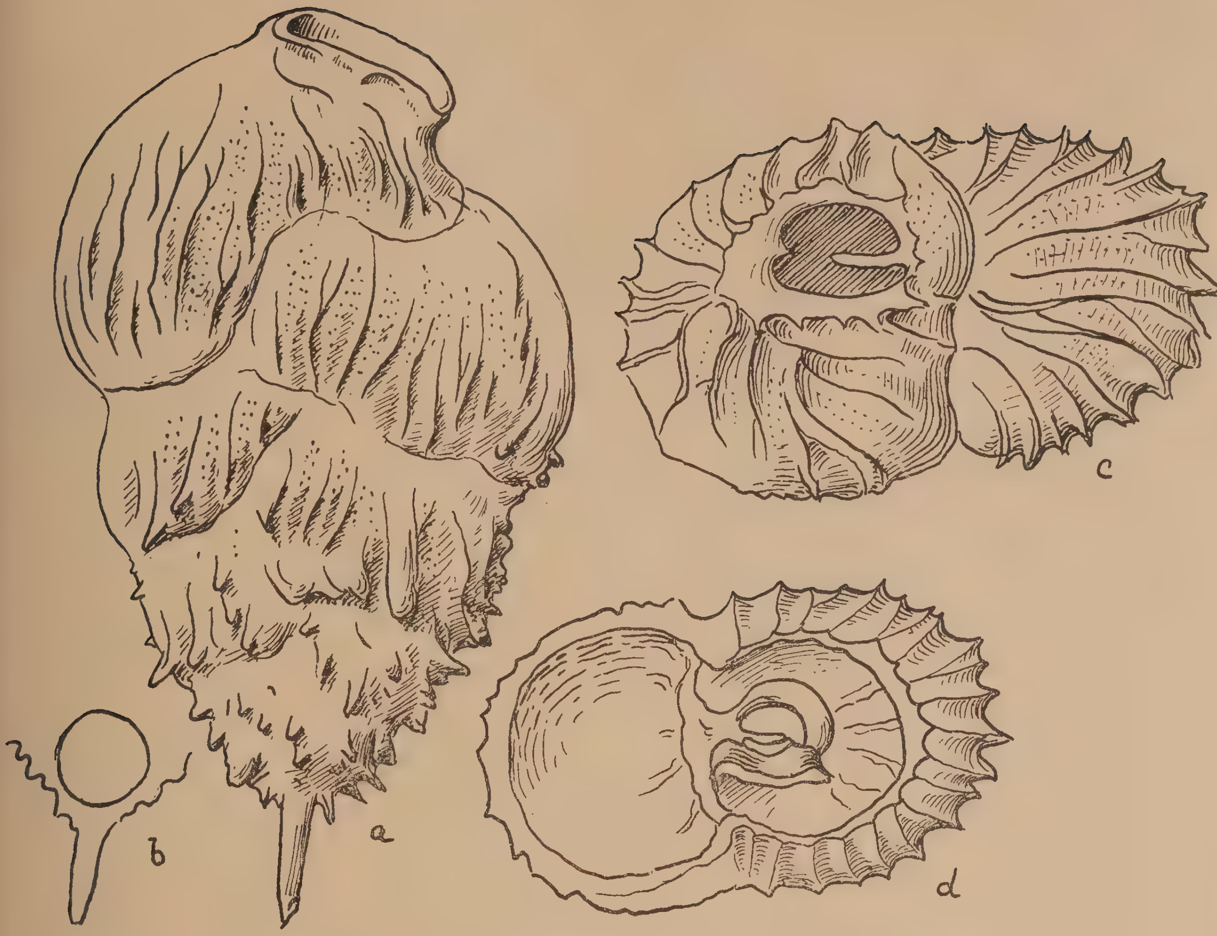


Fig. 38. *Loxostoma karrerianum* (Brady). A2-specimen. a, total shell; b, section through initial part; c, apertural face; d, transverse section through two chambers, showing toothplate in one of them, with the aperture of the former chamber and its tooth. × 480.

Bolivina tortuosa Brady
(Fig. 39)

This species occurred only rarely in stations south of Sumatra. The rareness of it may be due to the depth of the gatherings. It was found in only 8 specimens, all of them being of a single, megalospheric generation. Length of shell up to 0,21 mm, which is rather small, according to Cushman's measures.

It has been found at Station 2° 26′ S., 99° 35′ E., depth 582 fathoms in several specimens. Millet records it from the Malay Archipelago. Cushman found it at several Pacific stations mostly in shallow water. The toothplate is a simple one, but shows the peculiarity, that its back is likewise tortuose as the whole shell is: it is sigmoidal in shape.

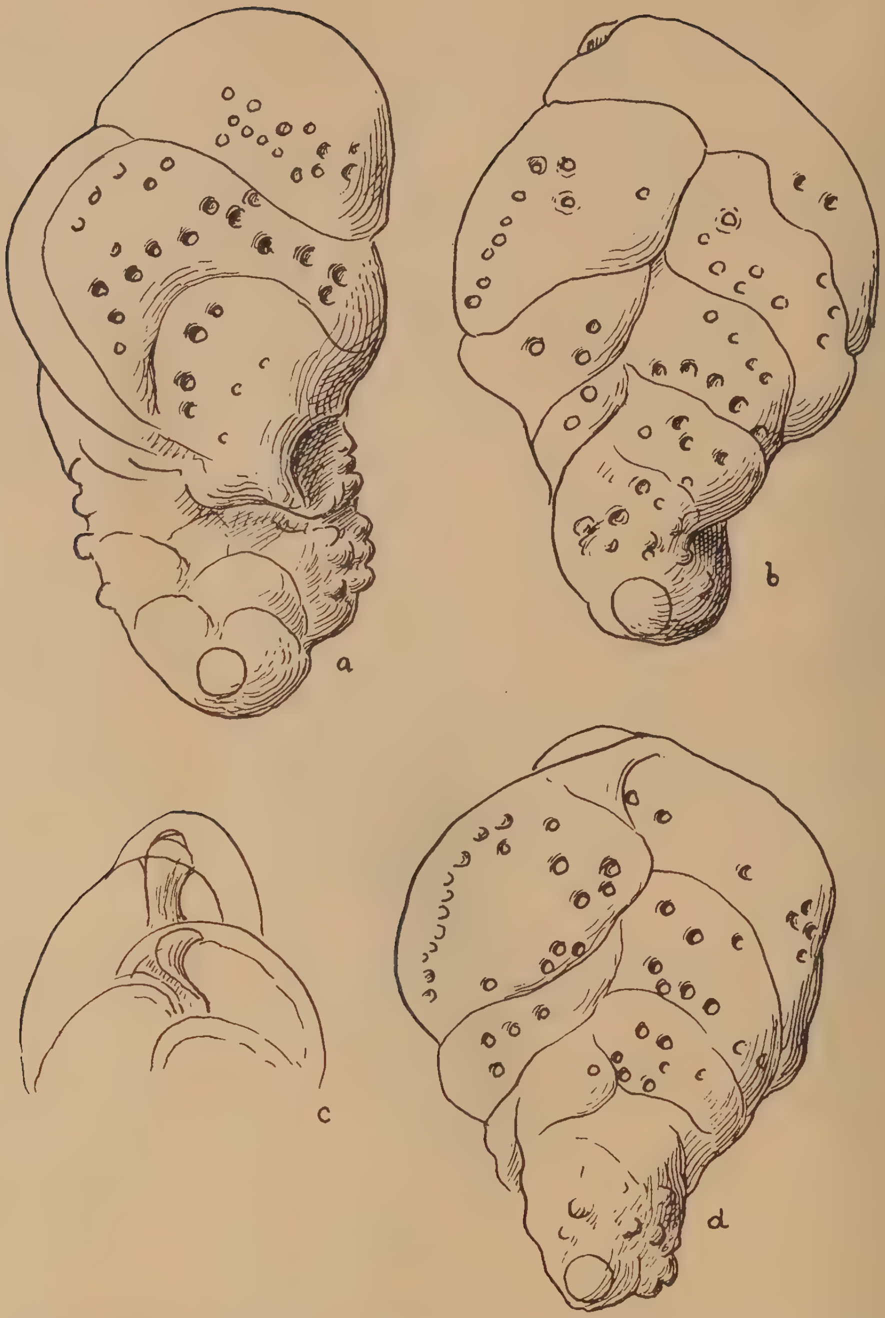


Fig. 39. *Bolivina tortuosa* Brady. a, specimen from aside, with the initial part flat; b, specimen with last-formed chambers laid flat; c, part of section, showing the toothplates; d, another specimen seen as b.

Bolivina robusta Brady
(Figs. 40-42)

This species is one of the commonest of the Archipelago. I found it as well in the gatherings south of Sumatra as in the those south of Sumbawa, and in other stations it occurred as well. It is a peculiar fact, that in the stations in the western part of the Archipelago the species occurs without an

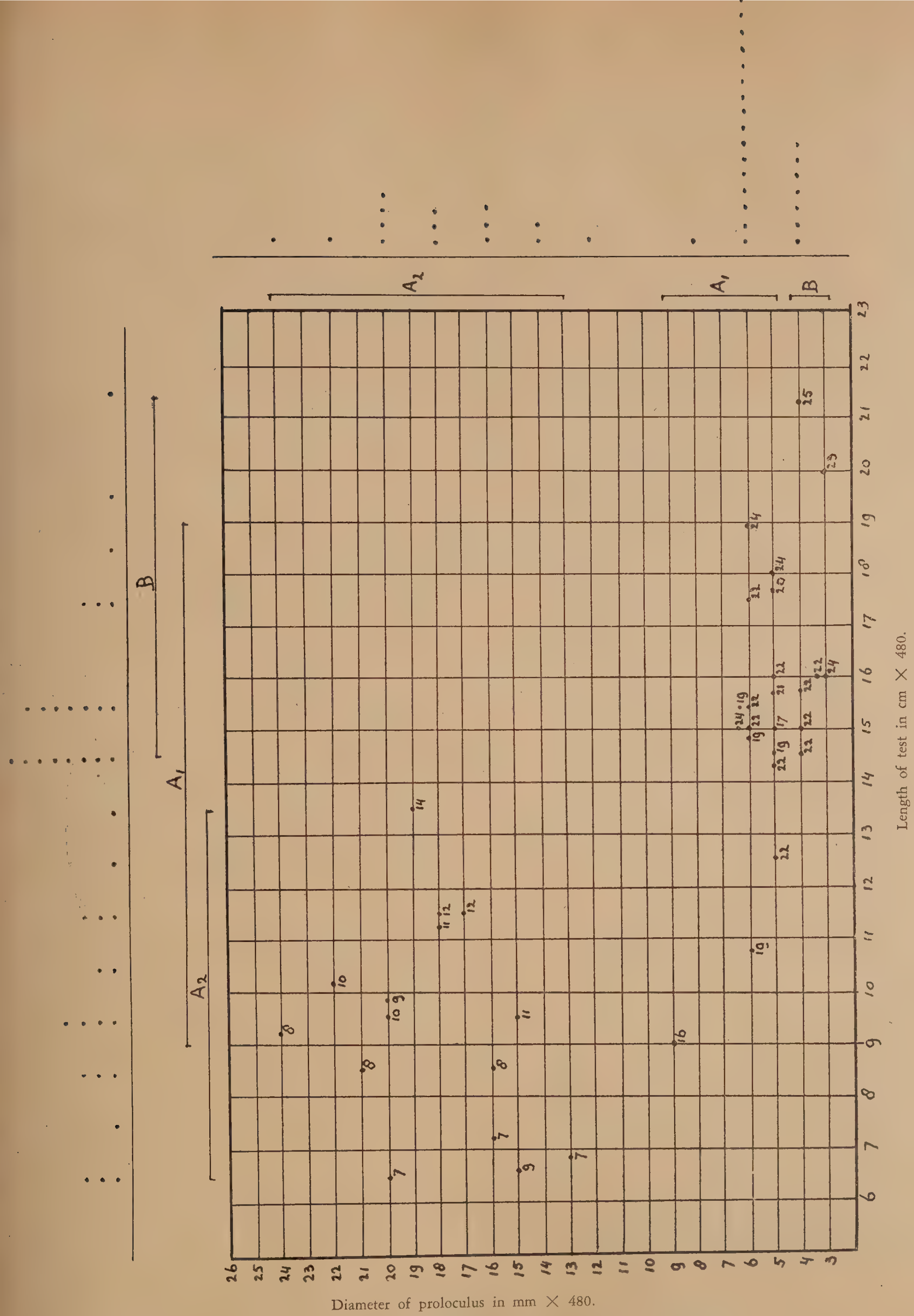


Fig. 40. *Bolivina robusta* Brady. Diagram showing relation between length of test and size of proloculus. The figures added give the number of biserial chambers.

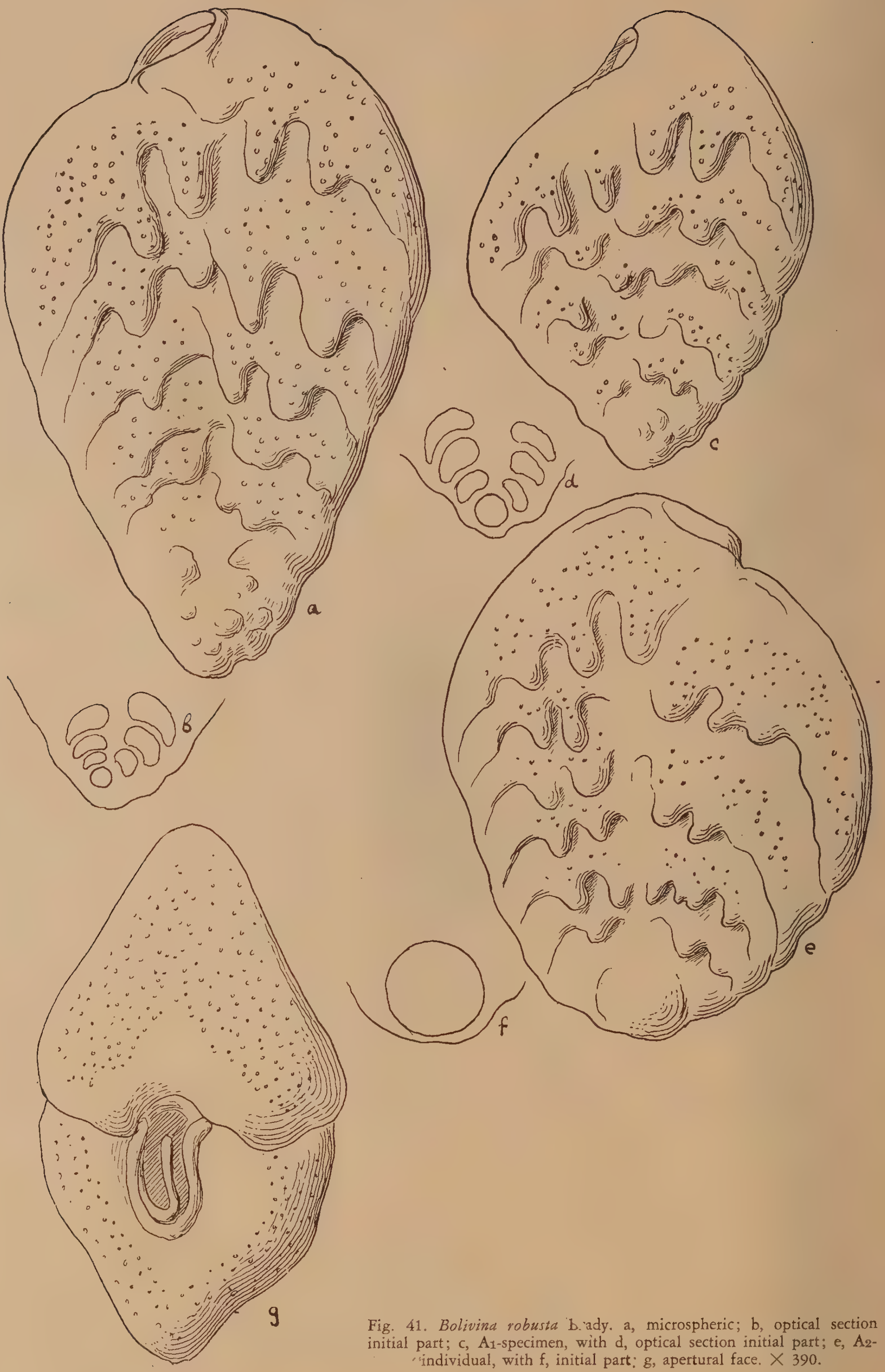


Fig. 41. *Bolivina robusta* Brady. a, microspheric; b, optical section initial part; c, A_1-specimen, with d, optical section initial part; e, A_2-individual, with f, initial part; g, apertural face. × 390.

initial spine, while in those of the eastern part often a large and well developed spine is present, as described by Cushman (1937, pl. 17, figs. 1 and 2); thus the forming of this spine may be due to circumstances.

In one station, 2° 17′ S., 99° 27′ E., depth 377 fathoms, bottom temperature 8°5 C., the species was extremely common, but very few specimens of the A-generation were found, most of them being B. This illustrates the fact that often in a special gathering only one of the generations is found, while in other samples one of the other generations may be dominant. This is also the case in geologic gatherings.

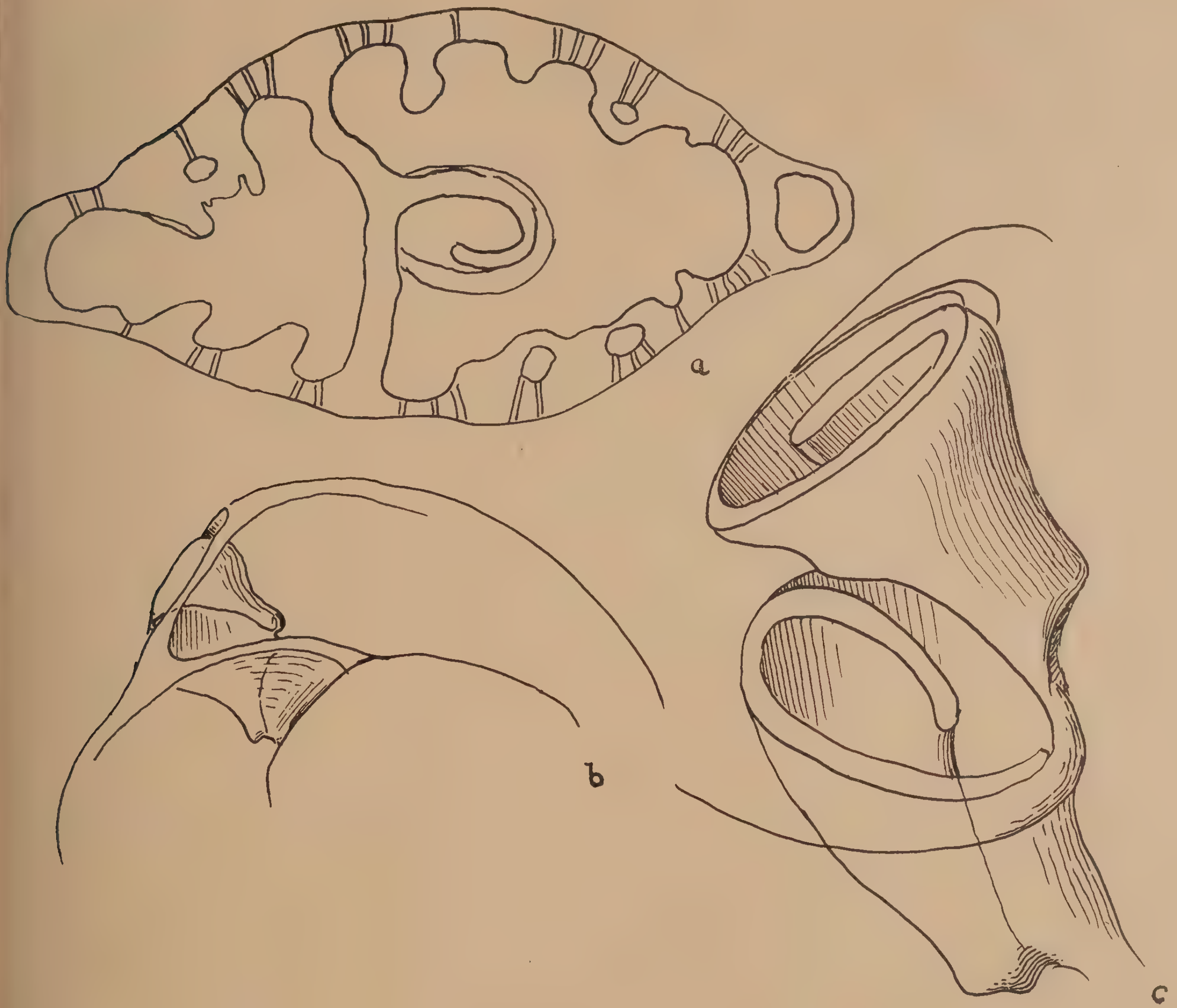


Fig. 42. *Bolivina robusta* Brady. a, transverse section, showing aperture with tooth, and the retral processes of the chambers; b, toothplates; c, theoretic drawing of the situation of the toothplates. a and b × 480.

B-generation. The proloculus diameter ranges from 6 to 8 μ, the length of the total shell from 0,30 up to 0,66 mm, breadth near the aperture from 0,17 up to 0,35 mm; relation between length and breadth being from 1,4 to 1,9. This generation shows always triangular shells, while the axis of the shell is the thickest part.

A_1-generation. Proloculus from 13 to 21 μ, length of the test from 0,22 to 0,60 mm; largest breadth from 0,13 to 0,35 mm. Relation between length and breadth from 1,6 to 1,8. The shells are stouter and the initial end somewhat more blunt than in the B-form.

A_2-generation. Proloculus ranging from 27 up to 50 μ, length of the tests from 0,12 up to 0,26, breadth from 0,11 up to 0,17. Relation between length and breadth from 1 to 1,6. Thus the tests of this form are nearly as long as broad, with very blunt initial end. The middle axis is not so thick as in the B-form, while the margin is somewhat more rounded. The retral processes near the sutures are not so well-developed as in both other forms.

These retral processes are formed by outgrowths of the chambers and not only by a thickening of the walls. The pores are fine, but are not found at the apertural ends of the side-walls. The margin is acute, without a carina. The aperture is an oval slit at the suture of the last-formed chamber, with a well-developed tooth, somewhat protruding from the aperture. The toothplate shows a triangular shape, the basal hook is not prominent, though well visible.

The species was found at following stations:
from 8-10° S., 118-123° E., 340-1015 fathoms depth;
from 1-10° S., 99° E., depth from 377-826 fathoms;
St. 159,0° 59′ S., 129° 48′ E., depth 411 m;
St. 262,5° 53′ S., 132° 48′ E., depth 560 m;
St. 159,5° 29′ S., 132° 52′ E., depth 487 m;
St. 49 a, 8° 23′ S., 119° 4′ E., depth 69 m.

The species may be identical with *Bol. acaulis* Egger (Meeresgrundproben Gazelle, 1895, p. 295, pl. 8, figs. 28-30) from the western shore of Australia.

Bolivina compacta Sidebottom
(Figs. 43-45)

For literature see Cushman, a Monograph of the Subfamily *Virgulinidae;* Cushman Lab. for For. Res., Special Publ. No 9, 1937, p. 135.

It occurred in numerous specimens in a sample gathered by the Steamer Van Gogh, at 377 fathoms depth, 2° 17′ S., 99° 27′ E., where the bottom-temperature was 8°5 C. It was found in other places too, but never in such abundance. It has been recorded from many other stations in the Pacific.

All three generations could be found in the material, and they differ not only in the shape of the initial end of the shell, but also in the structure of the surface.

B-form. Especially in the later-formed chambers the pores are finer than in the other forms, but in the first chambers they are as large and irregularly placed. The sutures between the chambers are very indistinct, as secundary chalk has grown over them and has smoothed the surface. But along the middle of the shell runs a longitudinal smooth ridge, which becomes somewhat irregular towards the apertural end. The initial end is much sharper than in the other two generations, but blunt also. The sides of the shell show a bluntly rounded margin. Length up to 30 mm, diameter of proloculus 8 μ.

A_1-form. Shell very slender, length: breadth as 15 : 5. Sutures not distinct, except in the

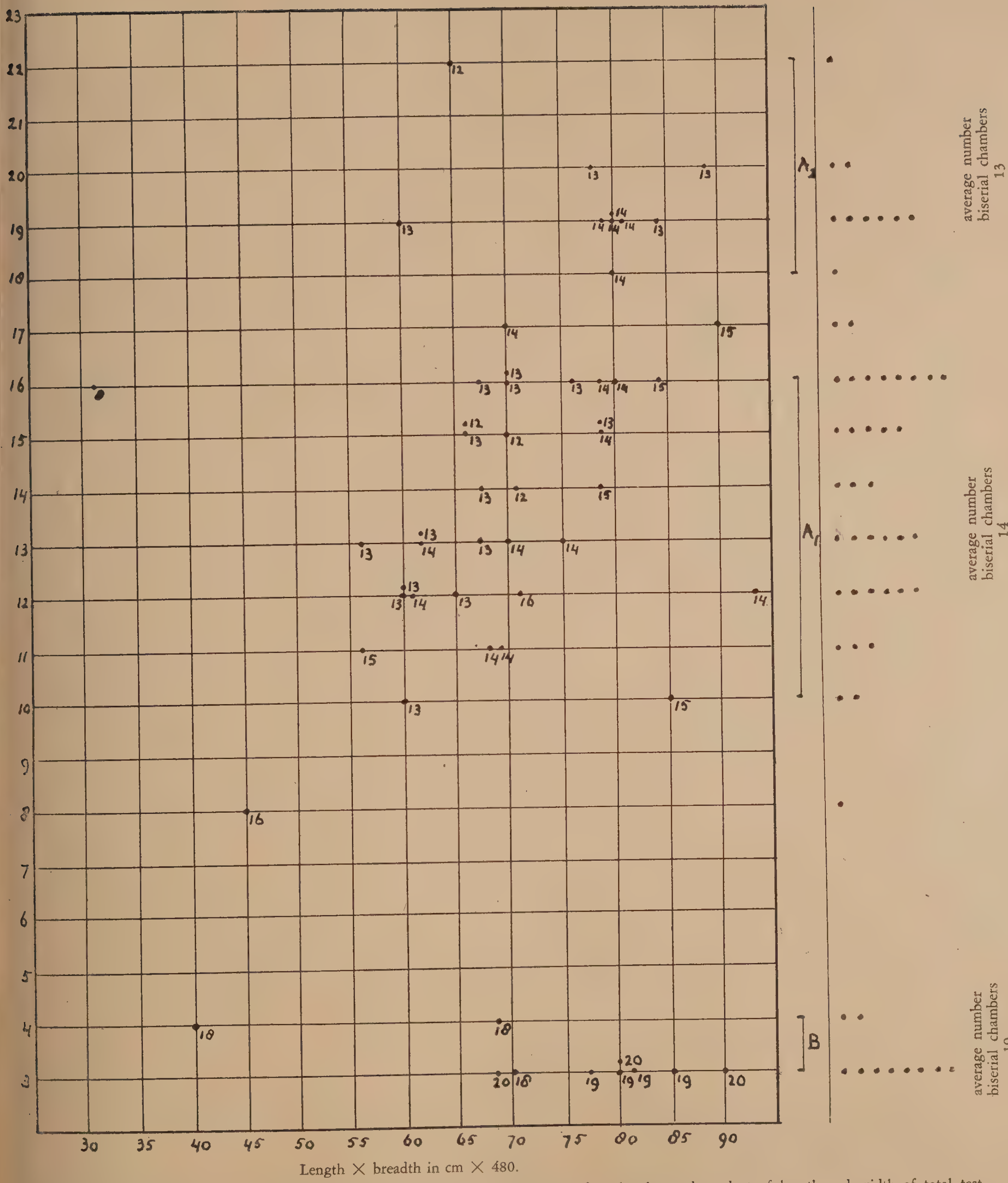


Fig. 43. *Bolivina compacta* Sidebottom. Diagram of relation between diameter of proloculus and product of length and width of total test. The figures added indicate the number of biserial chambers.

initial part of the shell, where they are slightly thickened by secondary chalk. Pores gradually becoming smaller towards the apertural end. Initial end bluntly rounded, but roughened by some pustules. Total length of shell about 0,30 mm, diameter of proloculus about 25 μ.

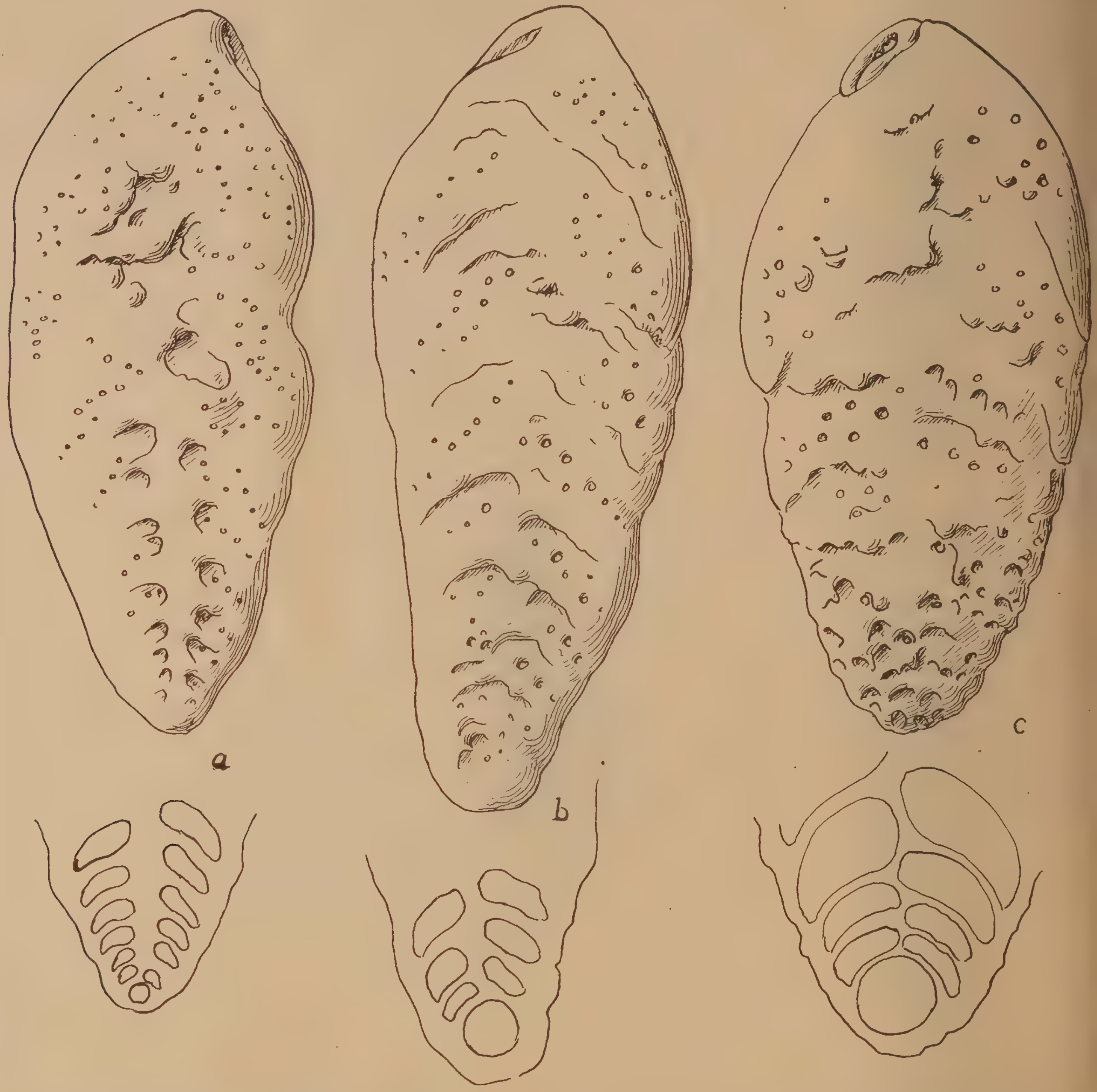


Fig. 44. *Bolivina compacta* Sidebottom. a, microspheric, with section initial part; b, A_1-specimen, with section; c, A_2-individual, with section, × 480.

A_2-form. Shell broader, length: breadth as 2 : 1. Sutures indistinct, but especially towards the initial end irregular outgrowths of secundary chalk project from the sutures backwards, so as to form the typical structure of the very closely allied form *Bolivina albatrossi.* Pores do not become smaller towards the apertural end. Initial end very bluntly rounded. Length of shell up to 260 mm. Diameter of proloculus 35 μ.

Special attention was given to the apertural conditions of the translucent species. As one knows, it is always mentioned, that in most *Bolivinae* the aperture is connected with that of the former chamber by means of a thin internal tube, and that in that tube is situated a small tooth. But when material of this species is laid in ricinic-oil, and seen in transmitted light, one discovers, that this tube is nothing else but a lamellum, of which one side, the free one, is curled into the tooth, which, in this species, is ornamented by very fine small teeth. Transverse sections through the shell, showed the exact situation. From one of the thickened lips of the former foramen a fine translucent chalk plate runs towards the opposite side-lip of the next foramen, and at its apertural end this plate is curled inward, thus giving rise to the tooth, mentioned already. The plate at its other end, most opposite to the tooth, abruptly ends in a sharp hook.

Statistical measurements showed, that three distinct groups could be traced, one being the B-group, with 10 specimens, with proloculus diameter about 6 μ, length of shell between 0,27 and 0,33 mm, breadth of shell about 0,12 mm. Number of chambers without proloculus 18-20, with an average of 19.

The A_1-generation showed a proloculus measuring in diameter from 25 up to 33 μ, with no distinct tops at 33 and 28 μ. Length of shell from 0,25 up to 0,31 mm, breadth about 0,10 mm. Number of chambers from 12 to 15, with an average of 15 in fullgrown specimens.

The A_2-generation shows a proloculus with top at 39 μ diameter. Length of shell from 0,25 up to 0,31 mm, breadth about 0,12 mm. Thus the breadth of these shells is somewhat larger than that of the A_1-form, so that the product of length and breadth, compared with the diameter of the proloculus, in the megalospheric generations shows an increase as the diameter of the proloculus increases. The number of the chambers however decreases in the same respect, for in this generation its average is 13.

This statistic study of a total of 55 specimens shows clearly, that in *Bolivina* the three generations also are represented; the B-generation was found in 10 specimens, the A_1-generation comprised 35 specimens, while the A_2-form was shown in 10 specimens. Thus the A_1-generation was the more abundant group in this gathering.

The species was moreover found, but always rarely in the following stations:

St. 164; 1° 42′ S., 130° 47′ E., depth 32 m;
St. 166; 2° 28′ S., 131° 3′ E., depth 118 m;
St. 204; 4° 20′ S., 122° 58′ E., depth 75-94 m;
St. 260; 5° 36′ S., 132° 55′ E., depth 90 m;
St. 262; 5° 53′ S., 132° 48′ E., depth 560.

It has been recorded by Cushman (1942) from numerous Albatrosstations, north of the Archipelago.

Description of the species:

Test elongate, tapering, somewhat 2 times as long as broad, periphery rounded, initial end bluntly rounded, especially in the A_2-form, apertural end obliquely rounded; chambers numerous, especially in the B-form, very slightly inflated; sutures not depressed and often covered with layers of secundary chalk, irregularly sawed at the initial border of the chambers around the pores; wall ornamented by coarse pores at the initial part, especially in the A-forms, but finer near the apertural end; aperture elongate, oval, from the sutures running up to the highest point of the chambers.

Length up to 0,33 mm, breadth up to 0,12 mm.

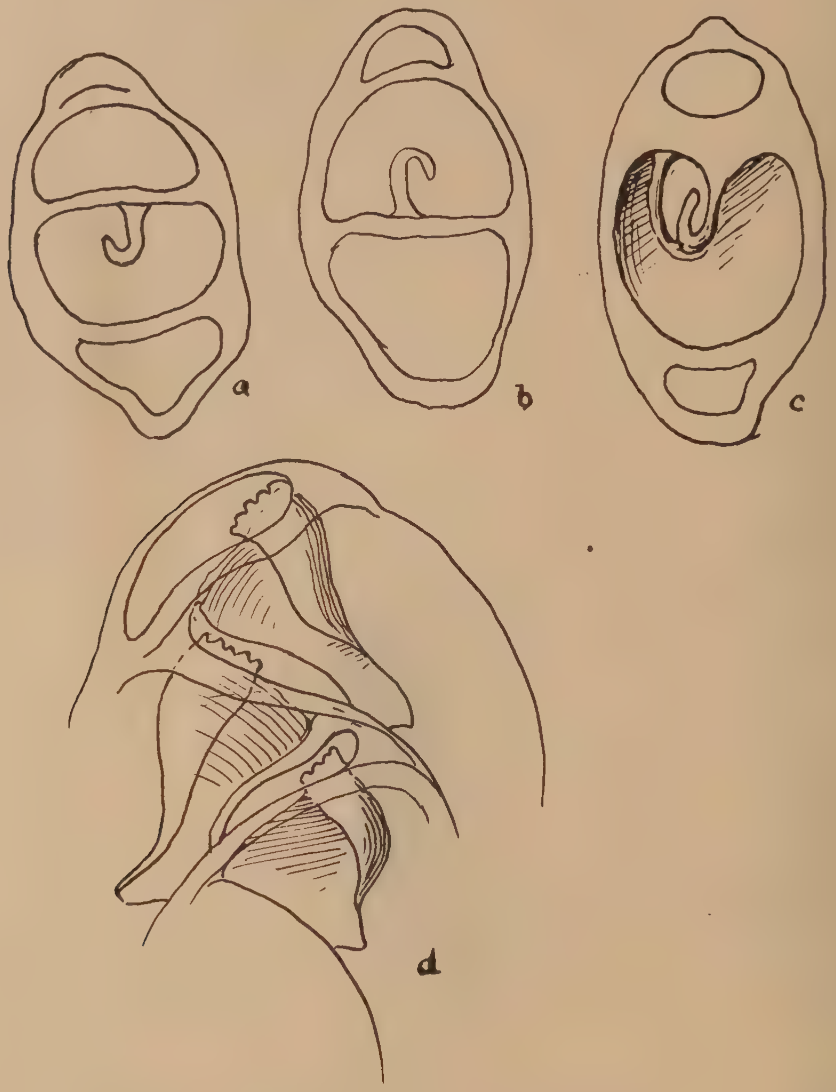


Fig. 45. *Bolivina compacta* Sidebottom. a, b, c, three successive sections, transverse, showing alternation of toothplate, c, with aperture; d, toothplates. × 480.

Bolivina albatrossi Cushman
(Figs. 46-48)

This species, with its typical network of ornamentation, occurred in some abundance in a gathering 1° 43′ S., 99° 32′ E., 826 fathoms.

The description of Cushman's in his standardwork on the Virgulininae (Spec. Publ. No. 9, 1937, p. 153, pl. 1, figs. 22-24) agrees with the specimens gathered here, except for the perforation, which according to Cushman is rather fine, while here only few and coarse pores are found.

An analysis of the specimens available showed, that the B-form represented by 6 specimens, had a proloculus of about 6-8 μ, a length from 0,26 up to 0,35 mm, breadth 0,09-0,11 mm. The wall of most chambers in this generation is rather smooth, except for the somewhat raised sutures; only the initial end shows the typical rough surface with its irregular network.

The A_1-generation, represented by another 6 specimens, has a proloculus measuring in diameter from 10 up to 17 μ, length 0,18 to 0,27 mm; breadth from 0,08 to 0,10 mm. Only the four last-formed chambers are smooth, more than half of the surface is covered with the irregular network. The initial part of the shell is somewhat more rounded than in the B-form.

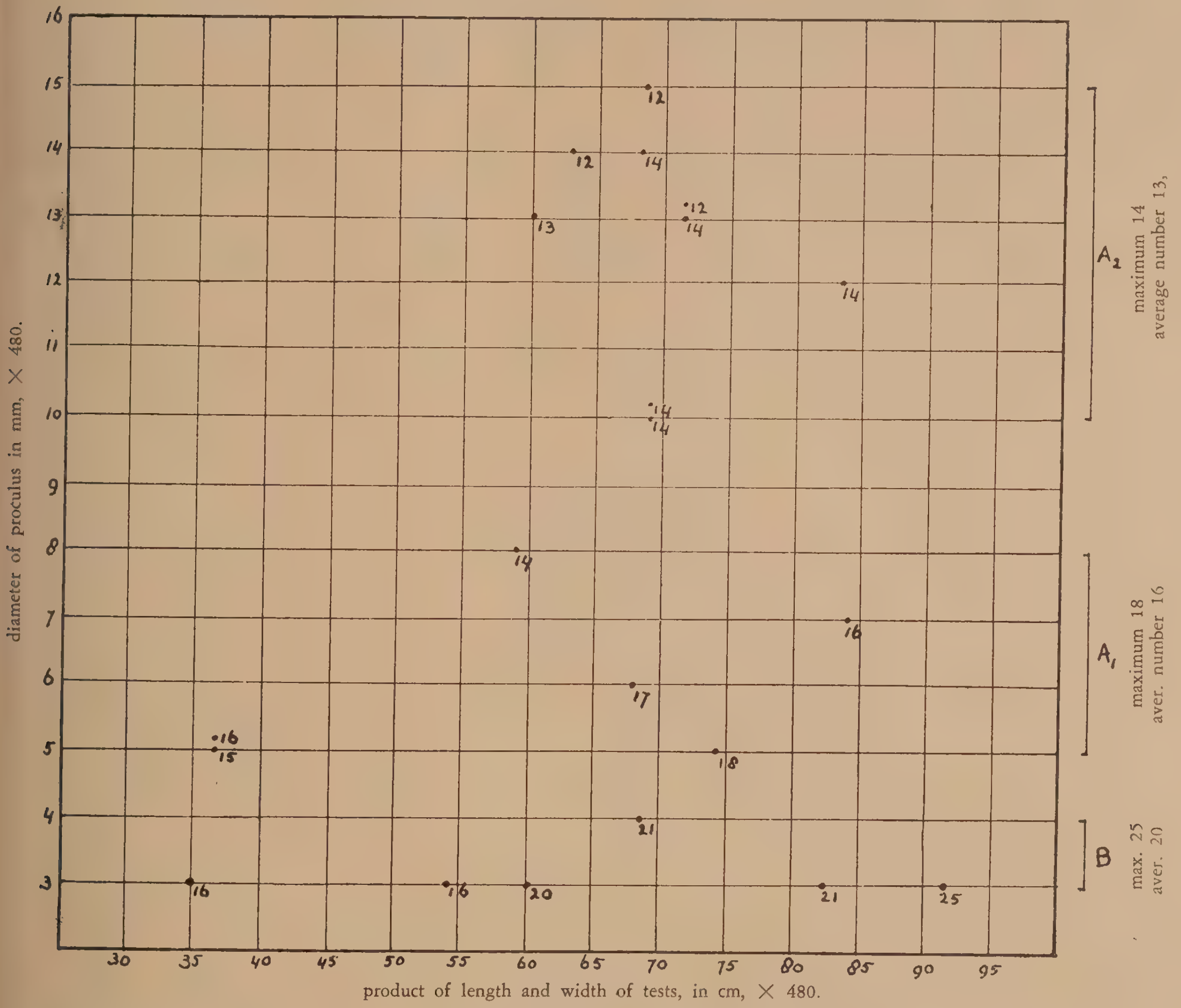


Fig. 46. *Diagram of Bolivina albatrossi* Cushman. Relation between diameter of proloculus and product of length and width of the test. The numbers indicate the total number of biserial chambers.

The A_2-form, with its more rounded initial end, has a proloculus with diameter from 21-31 μ. Length of shell 0,23-0,31 mm; breadth from 0,10-0,12 mm.

Transverse section shows a rather rounded periphery, while the test shows to be rather thick. Walls thick towards the initial end.

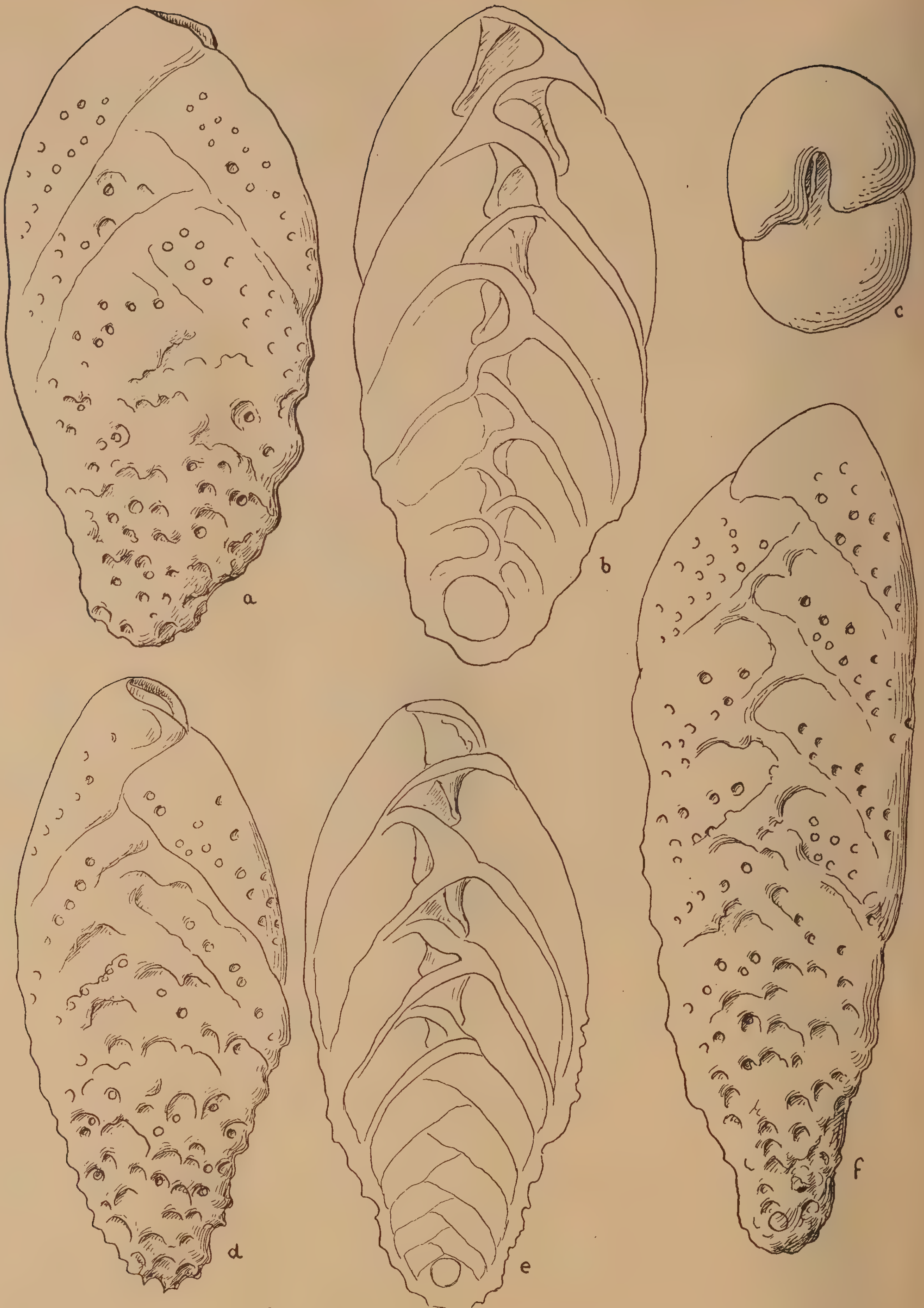


Fig. 47. *Bolivina albatrossi* Cushman. a and b, A_2-specimen, whole test and longitudinal section; c, apertural face; d and e, A_1-individual, whole test and section; f, microspheric specimen. × 435.

The toothplate shows the typical features of all *Bolivinae,* with a curved part near the aperture while the other end shows the typical hook. The plate is broad, without any teeth, and always is attached to the side of the aperture opposite to that from which the toothplate originates at the former aperture. This is of some interest, as another form, which I have called *Loxostoma cuneatum,* shows a very great likeness to our species, but is always distinguishable by its aperture and its straight, not curved toothplate.

Total number of chambers of the B-form 25 in adult; that of A_1-form is 16-18; the A_2-generation has only 14 chambers in the adult.

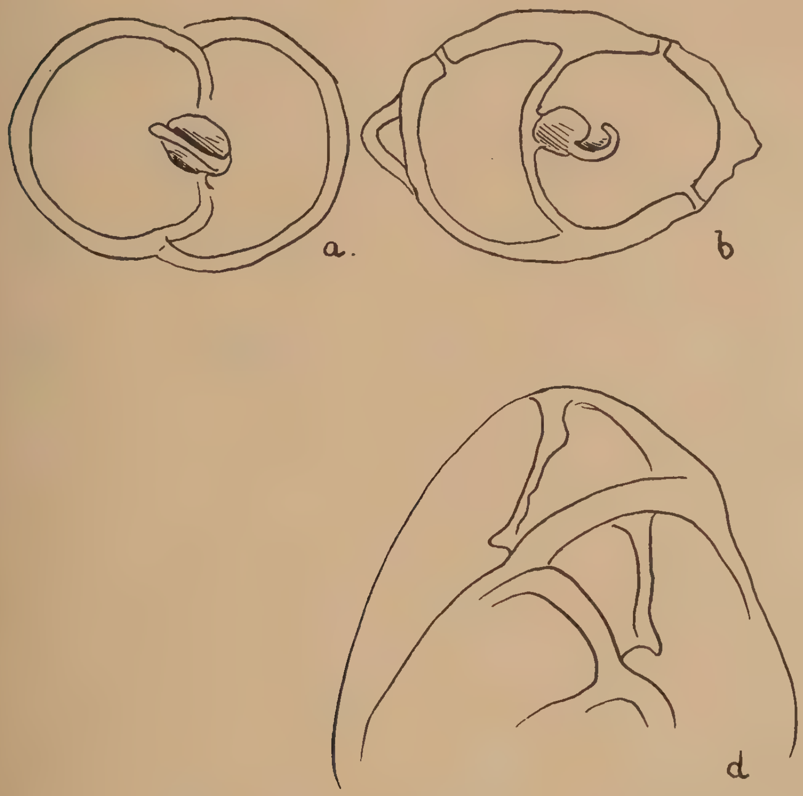


Fig. 48. *Bolivina albatrossi* Cushman. a, b, c, successive transverse sections; d, last-formed chambers with toothplates. × 480.

There is only a slight difference between the species and *B. robusta* Brady. So it may be, that the species, described here, in reality is *B. robusta* of many authors. *B. albatrossi* was as yet not mentioned from the Pacific, *B. robusta* was. From *B. compacta* the species is distinguishable by the toothplate and by its stouter form. In *B. compacta* the plate shows typical dentations at its tooth, in *B. albatrossi* the tooth is smooth.

Loxostoma cuneatum nov. spec.
(Figs. 49, 50)

Between normal *Bolivina albatrossi* Cushman in the gathering 1° 43′ S., 99° 32′ E., 826 fathoms, other specimens occurred, which at first were thought to belong to the normal type, but later on I observed, that the aperture from the beginning of the test was terminal, with a lip, and that the toothplate was straight and not curved, not showing an apical hook as in *B. albatrossi.* But the typical total form of the shell was the same, with its broadest part nearly at the middle of the shell, and the typical network of ornamentation at the initial part of the shell.

But as all three generations were found, this form must be totally different from *B. albatrossi,* and so I called it *Loxostoma cuneatum.*

B-generation. Proloculus 6-8 µ diameter; length 0,17-0,21 mm, breadth 0,07-0,08 mm. Whole shell, except two latest-formed chambers, covered with irregular network of protuberances. Chambers in adult 19 in number.

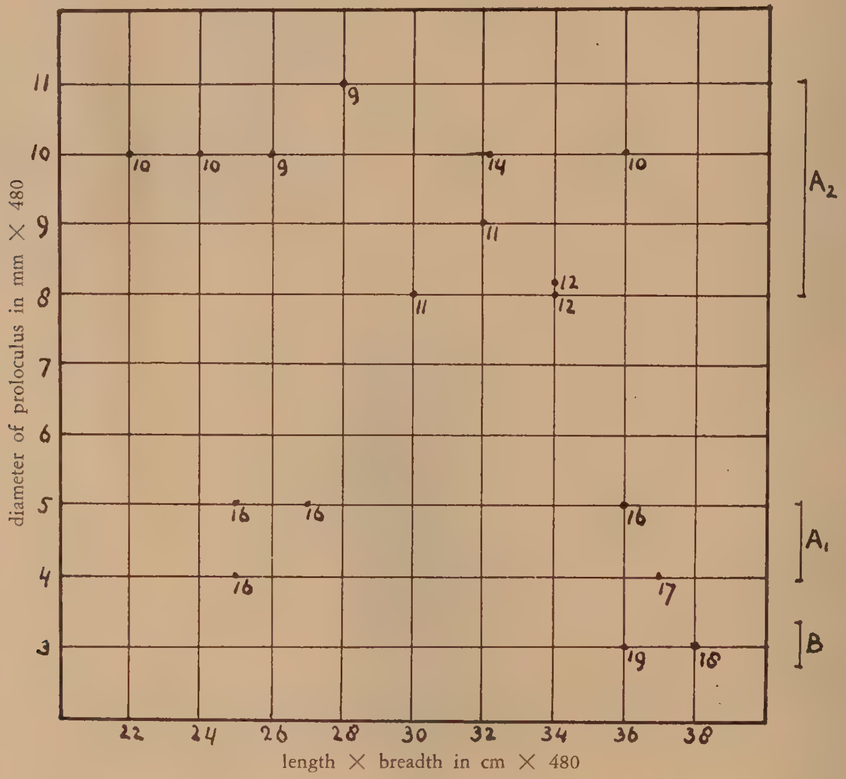


Fig. 49. *Loxostoma cuneatum* nov. spec. Diagram showing relation between the size of the proloculus and the product of length and breadth of the tests. The figures added indicate the number of biserial chambers.

A1-generation. Proloculus from 10-12 µ diameter. Length 0,17-0,19 mm, breadth 0,06-0,08 mm. Total number of chambers in adult 16 chambers.

A2-generation. Proloculus from 17-23 µ; length 0,15-0,21 mm, breadth 0,06-0,09 mm; total number of chambers in adult 12.

Thus the length of the shell is smaller than that of *Bolivina albatrossi,* and so is the breadth. The total number of the chambers is likewise somewhat smaller.

In transverse section the shell is rounded, as in *B. albatrossi,* with thicker walls in the initial part of the shell. The toothplate is not curved, but a straight plate running from one side of the former foramen towards the middle of the next one, and forming a straight tooth in that aperture, which is only attached to the wall of it with its base. This is a striking difference with *Bolivina albatrossi.*

The shell shows very little of the sutures of the chambers, and is covered for the most part by irregular ornamentation, which is lacking in the last-formed part of the shell in the B-generation, and in the A_1-generation the ornamentation is only found in the initial part of it. The wall shows very coarse and few pores, arranged in a row at each chamber not well visible in the A_2-generation by its very coarse ornamentation. The aperture is oval, at the antapical end of the shell; in the B- and A_1-forms the first chambers show bolivine mouthes, in the A_2-generation all mouthes are like typical *Loxostoma.* In the aperture is a straight tooth, dividing it into nearly equal halves. The mouth is situated on a very short neck and provided with a more or less distinct lip. The largest breadth of the shell is situated near the middle, and it is therefore, as the shell with its rough ornamentation

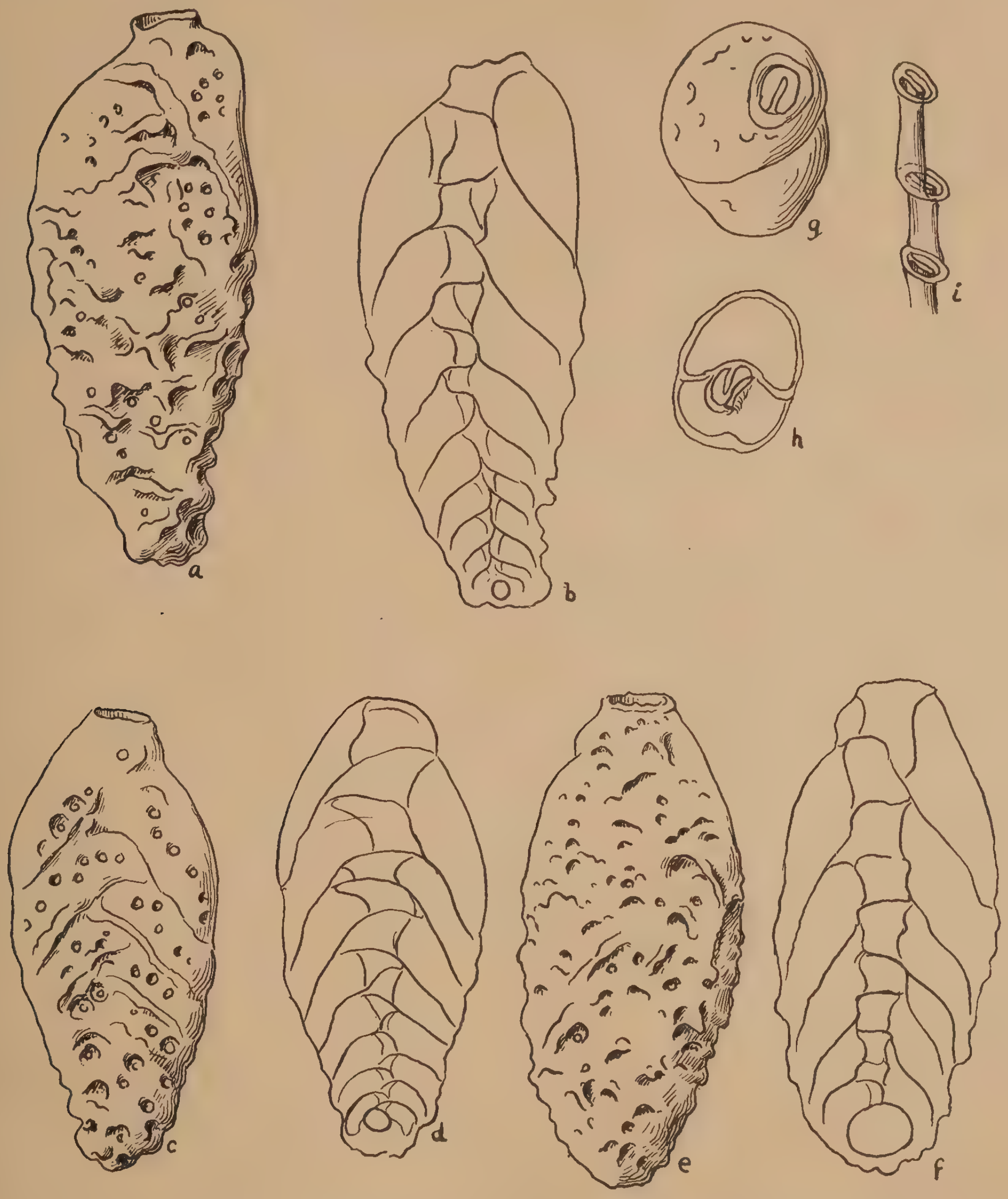


Fig. 50. *Loxostoma cuneatum* nov. spec. a, microspheric specimen; b, optical section; c, A_1-individual; d, optical section; e, A_2-form; f, optical section; g, apertural view; h, section through next chambers; i, toothplates. × 480.

resembles those artefacts, known as stone wigs from early human culture, I named it *Loxostoma cuneatum.*

Description:

Test elongate, with the broadest part about the middle. Margin broadly rounded. Chambers much more higher than broad. Sutures very indistinct, covered by the irregular ornamentation, especially in the A_2. Pores coarse in the thickened walls. Aperture terminal, an oval opening, divided in two equal parts by a straight tooth. Toothplate straight and hardly folded. Both ends of shell bluntly rounded.

Length up to 0,21 mm, breadth up to 0,09 mm.

The genus **Bifarina,** exit.

This genus has been proposed by Parker and Jones in 1872. They did not give any attention to the inner structure, and later authors have thus thrown together quite different forms in this genus, only laying stress on some outer characters. In this way the description of the genus, given in 1937 by Cushman (Cushm. Lab. Foram. Research, spec. publ., No. 9, p. 196) was established:

"Test with the earlier chambers biserial, later ones uniserial, uniserial portion making up most of the test in most species; wall calcareous, perforate; aperture in the young as in *Bolivina*, later terminal and rounded."

As one will observe, this description is also adequate for many species, gathered in the "genera" *Loxostoma* and *Rectobolivina.* For the rounded aperture in reality is seldom found and in many species it is more or less slit-like.

When studying the inner structure, especially that of the toothplate, I found, that Liebus' species *Bifarina adelae* belongs without any doubt in the close neighbourhood of *Rectobolivina dimorpha. Bifarina elongata* shows a very typical toothplate, which cannot be identified with any of the toothplates of *Bolivina* or *Rectobolivina,* and seems to be closest to those very typical toothplates, found in many species of *Bitubulogenerina,* whereas its initial part shows, as in that genus, the tendency to be triserial in its first part. *Bifarina mackinnoni* on the other hand begins with a triserial part, and not biserially, and shows no traces whatever of a toothplate, whereas the very typical walls show the structure of many of the *Valvulinidae,* so that I am convinced, that this species does not belong in any way to the bolivine group. *Bifarina fimbriata* showed to belong to the genus *Rectobolivina,* according to its toothplate.

All these facts show without any doubt, that species, belonging to *Rectobolivina, Bitubulogenerina, Valvulinidae,* have been gathered in this too superficially described genus, and that therefore this genus has to be altered. As genoholotype Cushman mentions *Dimorphina saxipara* Ehrenberg. But about this species Cushman says (l.c. 1937, p. 197): "The species is an unsatisfactory one, as it has not been identified by later authors from this region". The figure of Ehrenberg gives some inner structure which, though showing something like a toothplate, is not good enough to identify this plate. The species, which shows some toothplate resembling the rounded buildings, drawn in the figure of Ehrenberg's, is so-called *Bifarina elongata* Millet from the Malayan Archipelago, when seen from aside. But, as even this species *B. saxipara* is not a certain one, it will be much better to drop the whole genus, and to restudy the different species mentioned as *Bifarina,* especially in regard to their toothplates.

(Fig. 51)

Rectobolivina fimbriata (Millet)

This species has been found in a single gathering South of Sumatra (2° 26′ S., 100° 0′ E., 222 fathoms), and in several ones near Sumbawa.

The species is always a rare one, and only about 10 specimens came to view. The species is always recognisable by the texture of the shell, in the first stages being a single, somewhat irregular projecting ridge of clear chalk-substance round the broadest part of the chamber, in the older parts this ridge becoming broader, and, as the pores are situated in two rows just at the same place, these pores form wider openings in that ridge, which becomes in this way striate like a honeycomb. Especially in the A_1-generation uniserial chambers are developed.

B-generation. Proloculus 6-8 μ. No uniserial chambers, biserial chambers 10 in number with only a single ridge, then two chambers with the typical honeycomb-structure. (young specimen).

A_1-generation. Proloculus 13-15 μ diameter. Mostly uniserial chambers developed. 5 chambers with single ridge, then chambers with honeycomb-structure, but biserial; after this 5 uniserial chambers, all with honeycomb-structure. Aperture terminal, an oval opening. Uniserial chambers slightly compressed. In the aperture a long thin tooth, attached to the short side of the oval opening. Aperture with a lip.

A_2-generation. Proloculus 15-20 μ. 7 biserial chambers with single ridge, followed by 5-6 biserial chambers with honeycomb-structure. No uniserial chambers developed.

Length of B-generation 0,15 mm, length of A_1-generation 0,30 mm, length of A_2-generation 0,27 mm.

Uniserial chambers always oval in transverse section, in the biserial part the chambers are rounded.

The aperture of biserial chambers is nearly like *Bolivina,* stretching towards the basal margin of the chamber. But the toothplate is not like that of *Bolivina,* but like that of *Loxostoma,* being nearly straight and only slightly curved at the free side of it. In the uniserial chambers the toothplate runs straight towards the next aperture, only very slightly curved at both free sides, but not so as in *Rectobolivina.* Thus the toothplate indicates strongly the relationship with *Loxostoma* and not with *Rectobolivina.* In this way the genus *Bifarina* is a *Loxostoma* with uniserial chambers.

The species must be closely allied to *Loxostoma strigosum* and to *Bolivina spinescens.* In these three species, which form a well-defined group, the pores are somewhat coarse, and restricted to the initial parts of the chambers, while around these pores chalk-material is heaped up, forming in some cases honeycomb-structure, in other spines. The aperture in these species always shows a thickened lip, and the toothplate always is straight and without a free folded tooth. In *Bolivina spinescens* the test remains totally biserial; in *Loxostoma strigosum* it becomes *Loxostoma*-like, with tendency to become uniserial, and in *Bifarina fimbriata* it has reached its uniserial arrangement fully. It is certain, that with some other species, showing pores only at the initial part of the chamber-walls, these species form a distinct group, thus indicating, that the genera *Loxostoma* and *Bifarina* have no real significance in a systematic view. The first part of the test of *„Bifarina" fimbriata* shows striking resemblance to the test of *Bolivina inconspicua,* but for another arrangement of the pores. Thus I have put it as an offspring of this *B. inconspicua* though I placed it also in the neighbourhood of both species mentioned above (see diagram at the beginning of this genus).

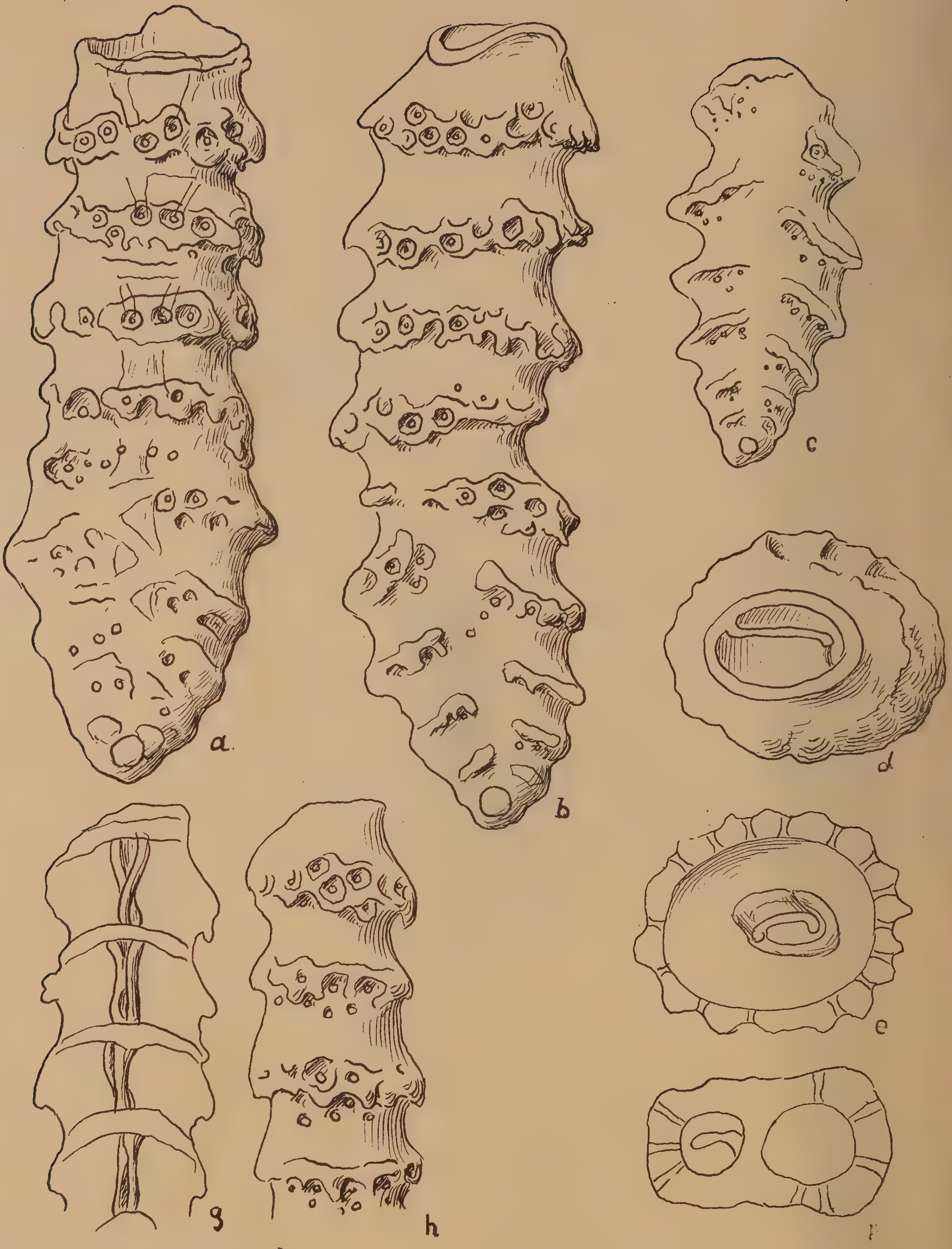


Fig. 51. *Rectobolivina fimbriata* (Millet). a, megalospheric specimen; b, another one; c, initial part of broken microspheric specimen; d, apertural face; e, transverse section through uniserial chamber, with toothplate; f, transverse section through biserial part; g, optical view from aside, showing situation of toothplate; h, same view, outside. × 480.

Millet records it from the Malay Archipelago, but nowhere abundant. The species *Bifarina mackinnoni* (Millet) was found to be of quite a different inner structure, so that it has not been described in this chapter.

Rectobolivina virgula (Brady)
(Fig. 52)

The species is a rare one in the gatherings south of Sumatra, depth from 405-777 fathoms.

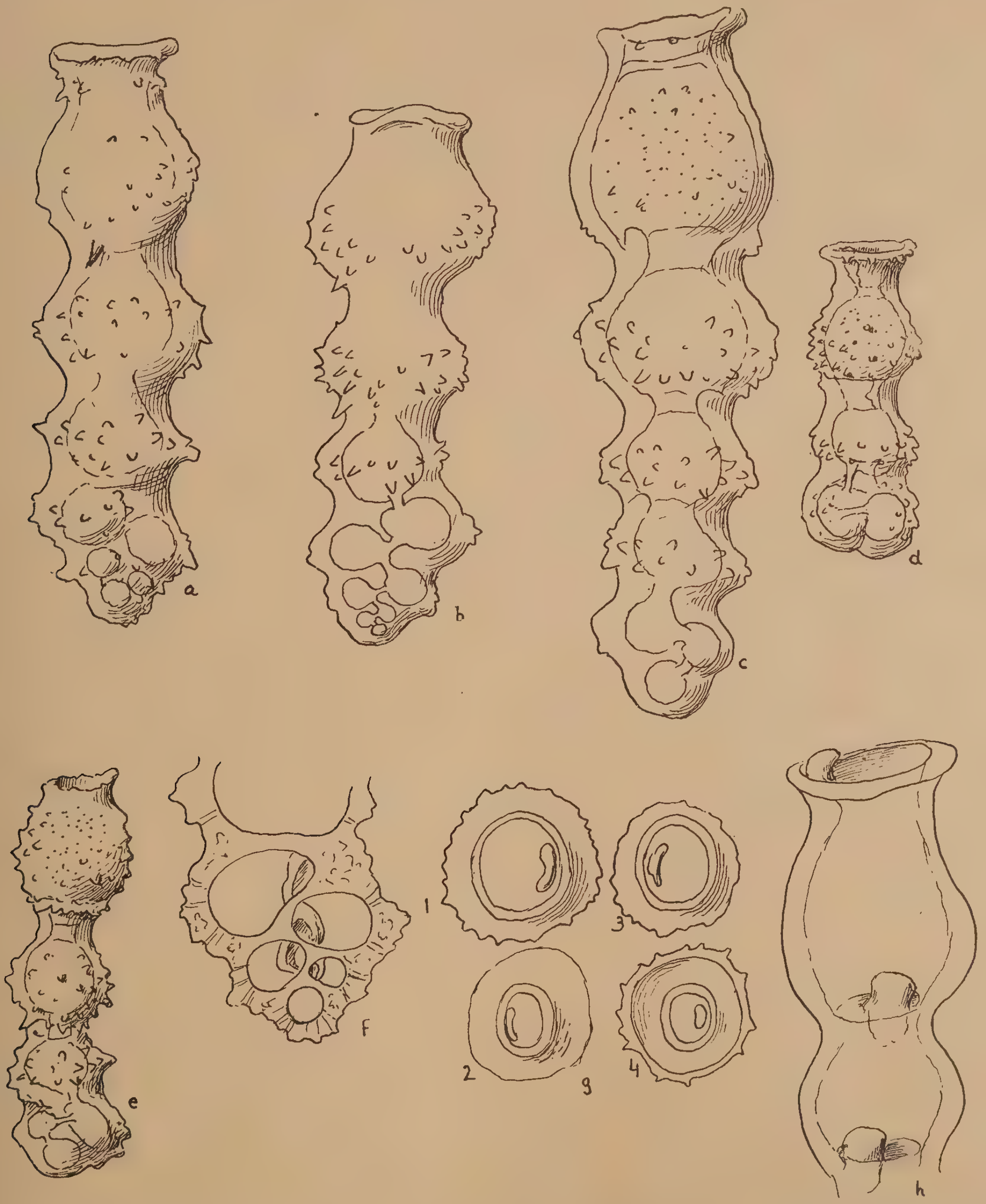


Fig. 52. *Rectobolivina virgula* (Brady). a, A1-specimen; b, B-form; c, A2-form; d, A2-form; e, A1-individual; f, longitudinal section through initial part of B-form; g, 1, 2, 3, 4, successive transverse sections, showing alternation of toothplate; h, optical section showing toothplates. All figures × 370, except fig. f, × 490.

It was abundantly found in anchor-mud off Merak, Strait Sunda. I found 6 specimens of which two may have been microspheric and four megalospheric. All show a beginning like a *Bolivina,* with biserial arrangement of chambers. In the microspheric form the proloculus has a diameter of 6 μ, and is followed by 5 biserial chambers. Then three uniserial ones are added.

In a megalospheric form with proloculus about 12 μ diameter, it is followed by 4 biserial chambers, and 3 uniserial ones are added. In specimens with proloculus about 20 μ diameter only two biserial chambers are found, while 2-4 uniserial chambers are added to them.

The aperture is a nearly round oval opening, with a sort of neck and a flaring lip. In this aperture a toothplate is found which, however, does not begin at the former aperture, but is totally formed by the last-formed aperture. The situation of this toothplate, which is a short and thick building, is always as in other *Rectobolivina*: the side of the aperture, at which it is found, alternates. The tooth is adjusted at the side, at which it is found, but it may be, that the real toothplate is absorbed after the building of the tooth. In the first uniserial chamber remains of the toothplate at its base, and at the lip of the aperture were found.

In the microspheric form at least, a real not absorbed or reduced toothplate is found in the biserial chambers, thus proving, that the species belongs to the genus *Rectobolivina.*

The species was first named by Brady as *Sagrina virgula,* afterwards by Cushman as *Siphogenerina virgula.* As the toothplates in the uniserial part are alternating, and not situated in an angle of about 120°, and as in the microspheric part the chambers are totally arranged biserially, there is no reason to call the species *Siphogenerina,* but it has to be incorporated in the genus *Rectobolivina.*

The texture of the walls with their short spines, especially at the apical end of each chamber, shows a striking resemblance to those forms, showing spines, assembled in the genus *Nodogenerina.* I myself studied *Nodogenerina spinulosa* (Montague) from the Paleocene of the Netherlands, and came to the conclusion, that, though in megalospheric specimens no trace whatever of a biserial arrangement can be found, here too a very much reduced, but alternating toothplate occurs. As no microspheric specimens of this species were found yet, I cannot be sure, whether in the microspheric form of *Nodogenerina* biserial chambers are found or not, but the other characteristics are undoubtedly pointing to the conclusion, that *Nodogenerina* has nothing to do whatever with *Nodosaria,* in which genus former authors incorporated *Nodogenerina,* but that it is an offspring of *Rectobolivina,* especially of forms, allied to *Rectobolivina virgula.*

Bolivina pygmaea Brady
(Fig. 53)

The species is rare, and occurred in some specimens, one microspheric and the other megalospheric, at St. 8° 15′ S., 118° 56′ E., depth 340 fathoms.

It may be taken for a young *B. alata,* but the sutures are nearly straight, the chambers low, the margin is not carinate, and only the points of the spines are without pores which have the same large size as in *B. alata,* and are not fine, as Cushman mentions. The tests are much smaller than those of *B. alata.* The toothplate is quite unlike that of *alata,* showing a broad, fan-like free part, no definite hook at its base, and a smooth free border, without any dentation. Only at the top of the free end which projects slightly from the mouth, some small sawings are found.

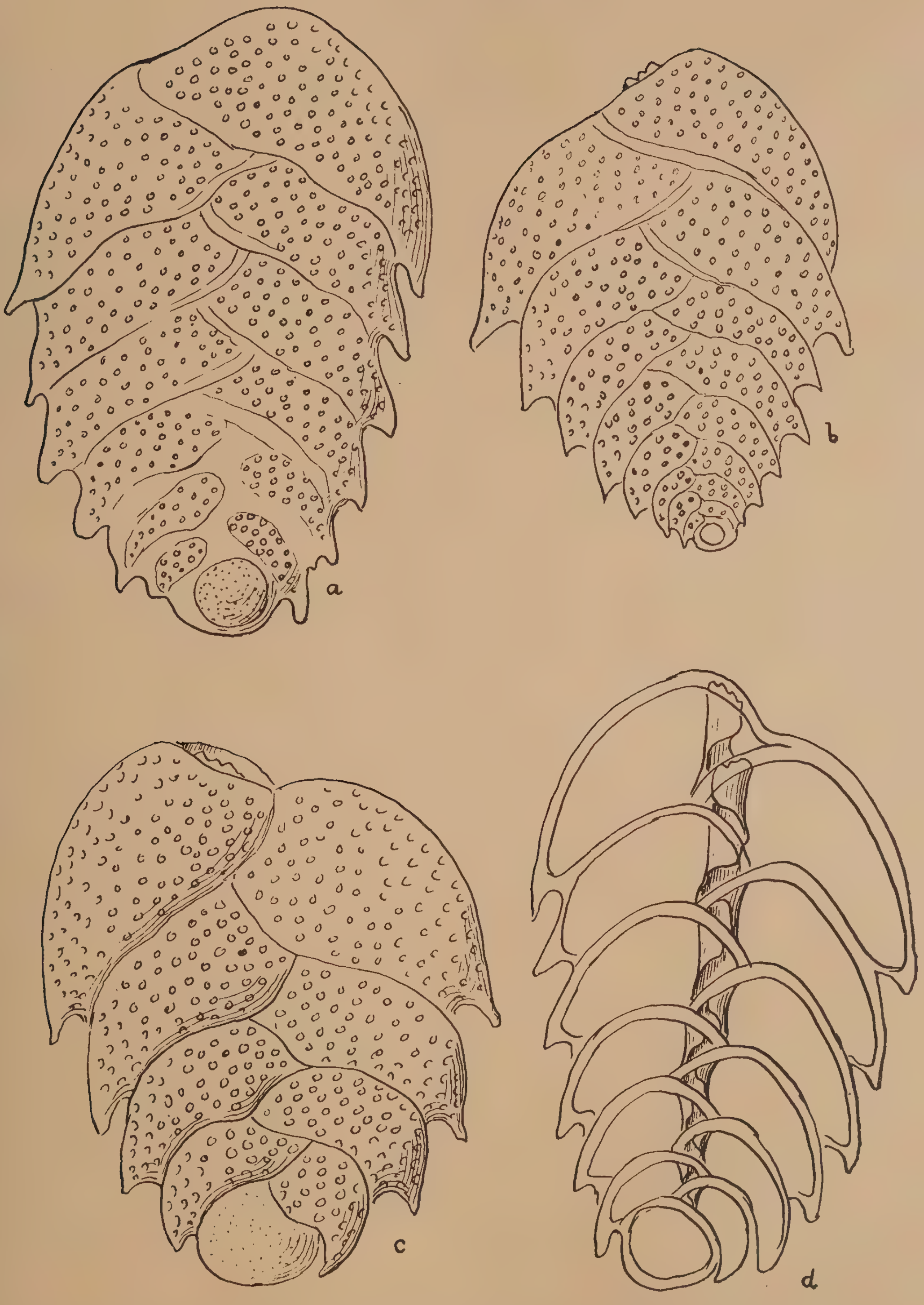


Fig. 53. *Bolivina pygmaea* Brady. a, Specimen of A1-generation; b, microspheric individual; c, Specimen of A2-generation; d, section, showing the overlapping chambers and the toothplates. × 480.

Diameter of megalospheric proloculus: 21 μ, length of shell 0,21 mm, width of shell 0,13 mm, total number of chambers 12.

Diameter of microspheric proloculus 8 μ, length of shell 0,17 mm, width of shell 0,12, total number of chambers 16.

Diameter of megalospheric proloculus, obviously belonging to A_2, was 40, length of shell 0,18 mm, breadth 0,15, total number of chambers 8. In this form the chambers are somewhat more inflated.

Description:

Small, not elongate tests, somewhat higher than broad, with inflated chambers. Sutures of chambers distinct, oblique and curved, each chamber ending in a spine at the margin. Margin sharp, but without carina. Chambers regularly and coarsely porous, except for the proloculus which has always very fine pores. Aperture an oval opening at the suture, with dentated short tooth. Toothplate simple, without real basal hook, with folded free part ending in a sawed tooth. The back of the toothplate is standing nearly in the direction of the axis of the shell.

Length up to 0,21 mm, breadth up to 0,15 mm.

Bolivina alata (Seguenza)
(Fig. 54)

This species occurred only in a gathering about 2° S., 99° E., south of Sumatra, in a depth of 582 fathoms, with a bottom-temperature of 6,6° C, and at 9° 20′ S., 120° 16′ E., 285 fathoms.

It shows the typical features of the species, described by Cushman (Spec. Publ., No. 9, Cushman Lab., 1937. p. 106-107).

The walls of all chambers are perforated by moderate large pores only at their initial part.

The aperture reaches in most cases the base of the chamberwall, the toothplate shows the typical bolivine character, but the hook at its base is rather small, thus indicating its resemblance to that of *Loxostoma.*

All individuals showed a rather large proloculus of about 21 μ diameter, thus indicating, that they belong probably to the A_2-generation.

Description of the species:

Test elongate, somewhat variable in relative length and breadth, very much compressed, the periphery sharp, with a keel at each chamber, but not with a keel, reaching over the chambers. Each keel of chamber ends in a flattened and often pointed spine, turned back toward the initial part. Chambers distinct, as the higher part of each chamber lacks pores, gradually increasing in height, overlapping at the margin, slightly inflated. Sutures distinct, often very much curved, especially in the later portion. Wall smooth, with rather coarse pores which in the earlier parts of the test are sunken down between spinous chalkmasses. Aperture sutural and very elongate, with protruding smooth tooth. Toothplate with basal hook, free flange distinctly sawed, but upper end of tooth bluntly broken off and smooth.

Length 0,50-0,75 mm, breadth 0,20 mm.

There exists much controversy about the name of the species, as *Bol. pygmaea* and *Bol. beyrichi* have often been confused with the species. Cushman described the latter species from recent gatherings under the name of *B. pseudo-beyrichi.* When considering the several species mentioned here, there is only one characteristic, which leaves us without any doubt, viz. the toothplate.

In *B. pygmaea* the toothplate is simple, with no basal hook, but with slight dentation at the end of the tooth; in *Bol.* (*Loxostoma*) *beyrichi* the toothplate shows, as in *B. alata,* a sawed free border, but the plate shows no basal hook, and is more of the type of typical *Loxostoma,* with the attached end becoming free; in *Bol. alata* the toothplate shows a distinct basal hook, the attached part is not free but for its end, and especially the hook is typical.

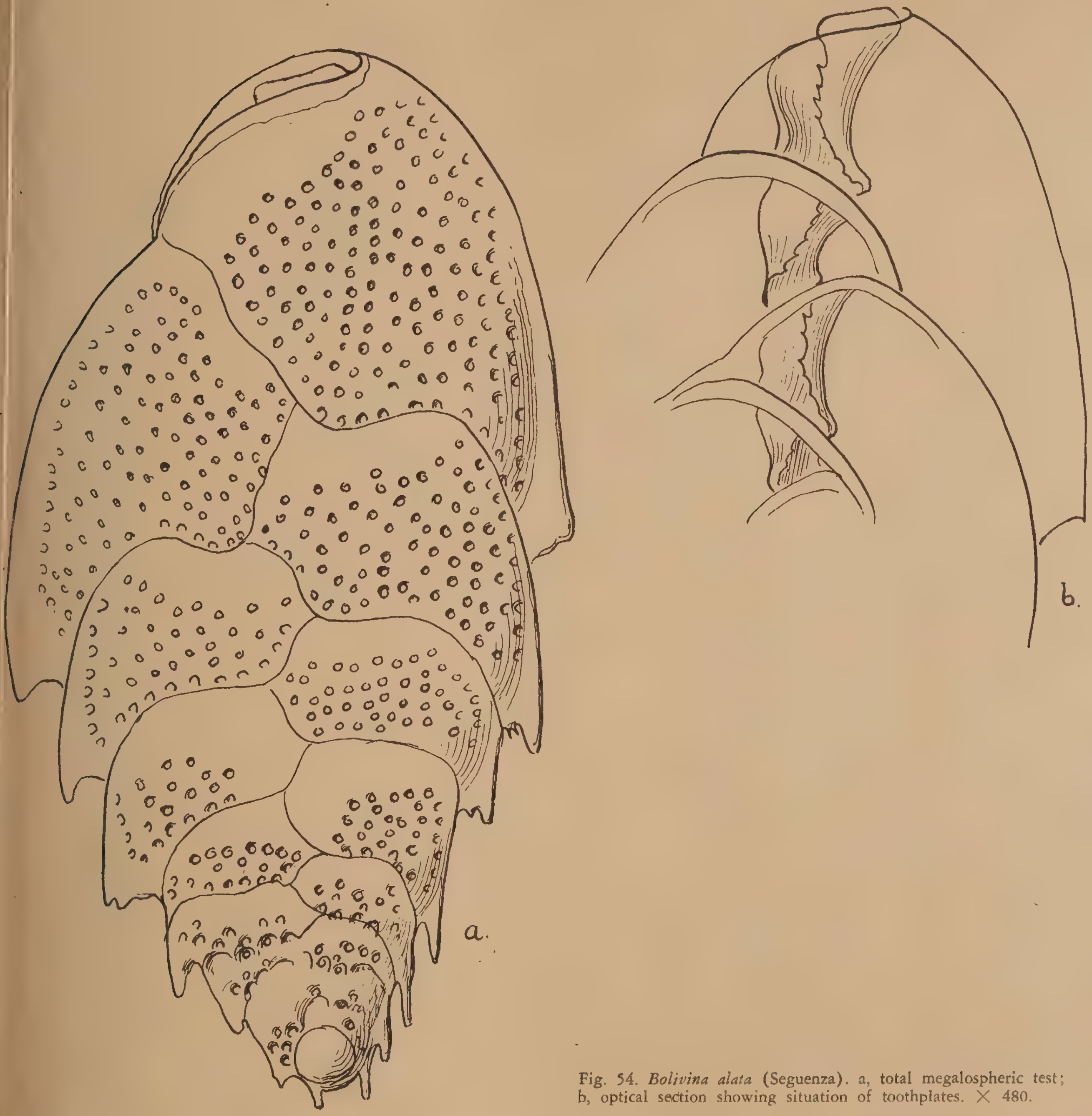


Fig. 54. *Bolivina alata* (Seguenza). a, total megalospheric test; b, optical section showing situation of toothplates. × 480.

Bolivina hantkeniana Brady
(Figs. 55-58)

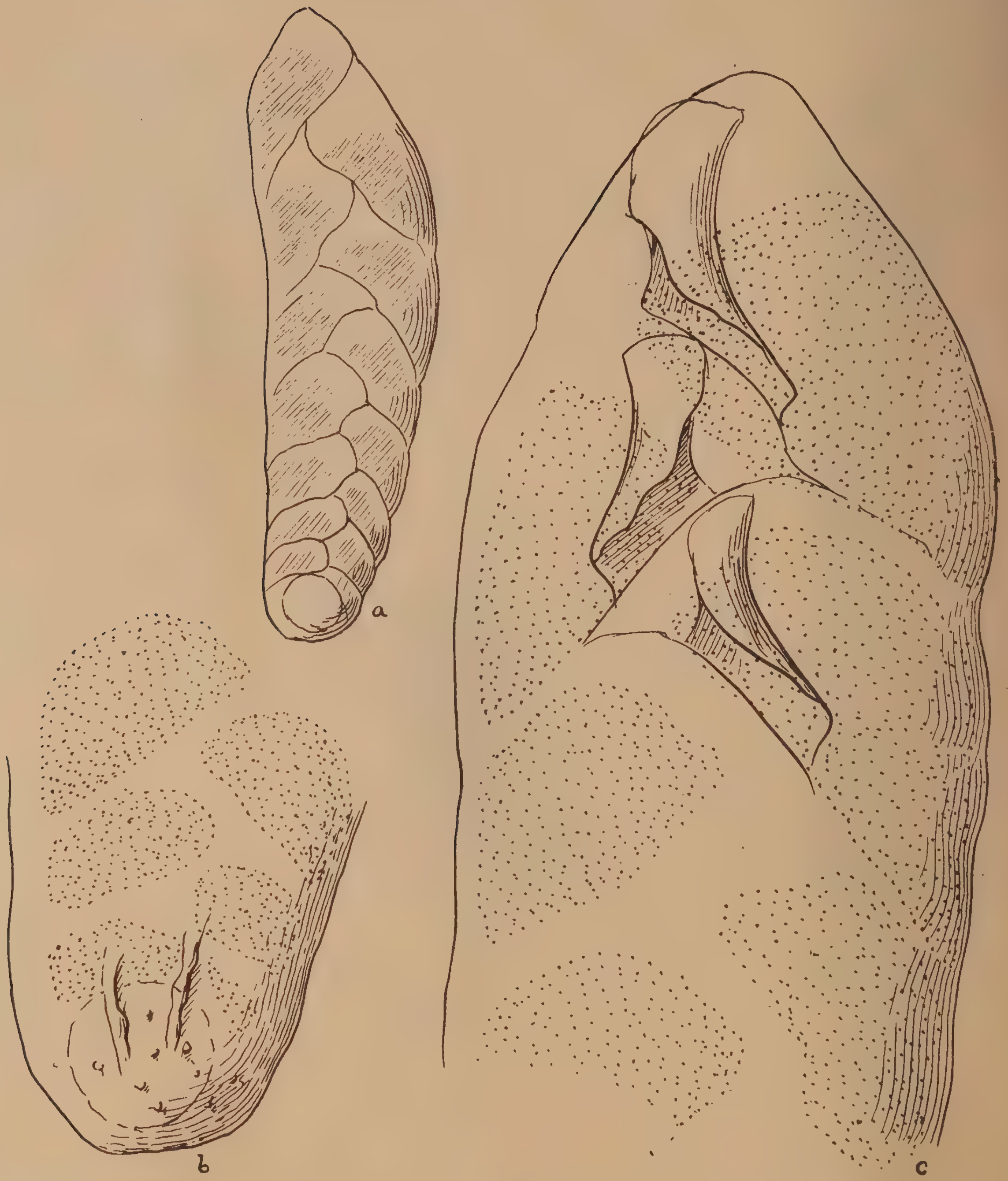


Fig. 55. *Bolivina hantkeniana* Brady. A_2-form. a, total specimen, × 100; b, initial part, showing very small costae, × 480; c, apertural end, with toothplates, × 480.

As Cushman stated already, there are different forms, which differ in the one having a broad irregular hyaline carina, while the other one shows no carina at all and is more slender. It showed to be the A_2-generation, while the large, broad forms with a comparative small test are A_1, and those with large test are B-forms. The species is very variable, and can only be distinguished

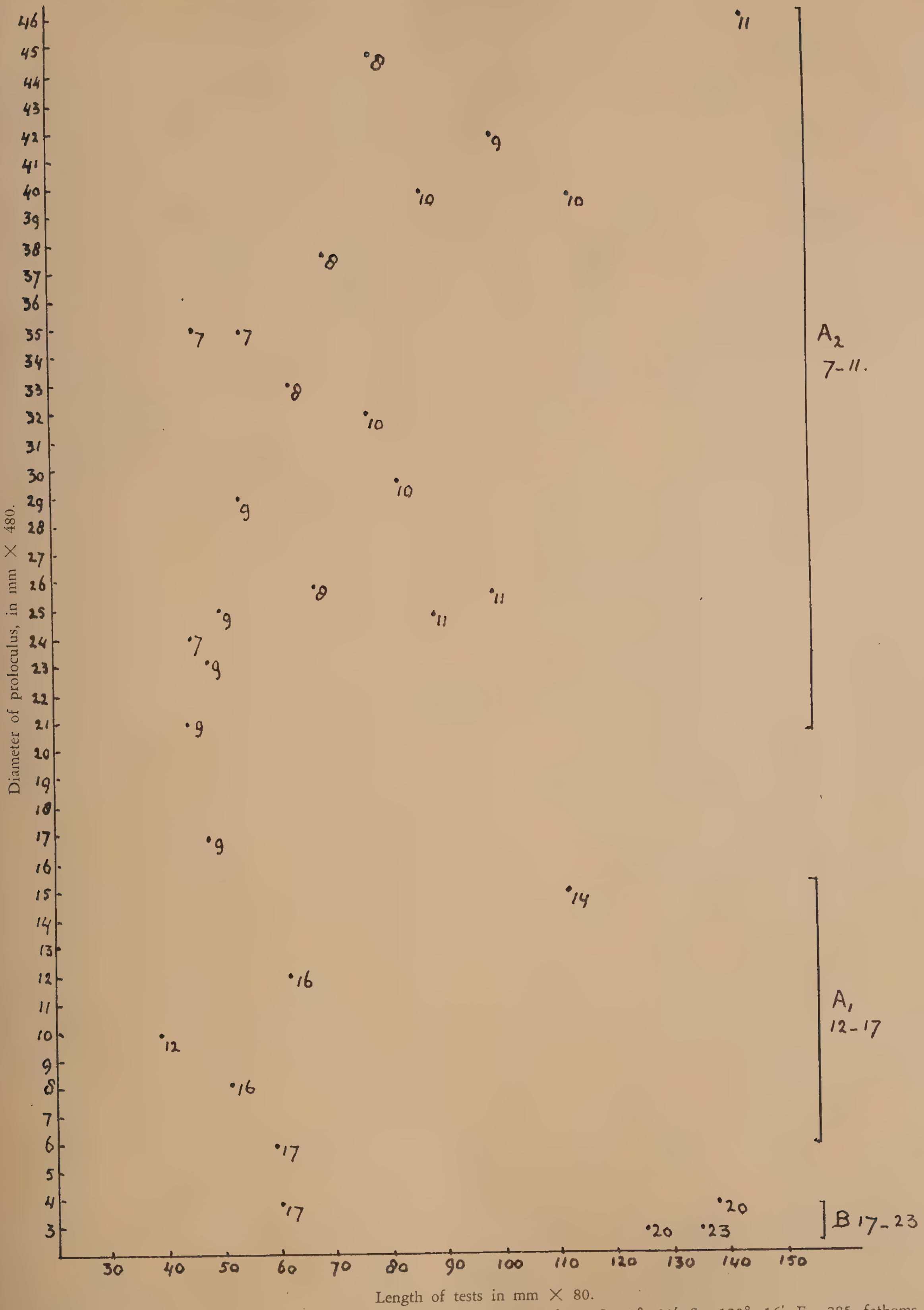


Fig. 56. *Bolivina hantkeniana,* the keeled variety. All specimens from St. 9° 20′ S., 120° 16′ E., 285 fathoms. Relations between size of proloculus and length of test; the figures added indicate the number of chambers, following proloculus.

without doubt by means of the toothplate, which is very characteristic, with its largely developed free plate, ending in a large, smooth tooth, and its well-developed hook at the base. The species occurred only in the stations around Flores, not in those south of Sumatra. It was found in some abundance at St. 10° 00′ S., 119° 19′ E. near Sumba, depth 453 fathoms, and at St. 8° 11′ S., 118° 43′ E. N. off Sumbawa, depth 1015 fathoms. Other characteristics which are typical for the species are the broad, thin, uninterrupted but irregularly bordered flange, the sutures of the chambers, which show a distinct angle in their middle, except in the A_2-generation, in which the short, longitudinal costae, typical for the generations with small proloculus are almost lacking. An other characteristic which is only found in the A_2-generation, is the lack of pores near the apertural suture.

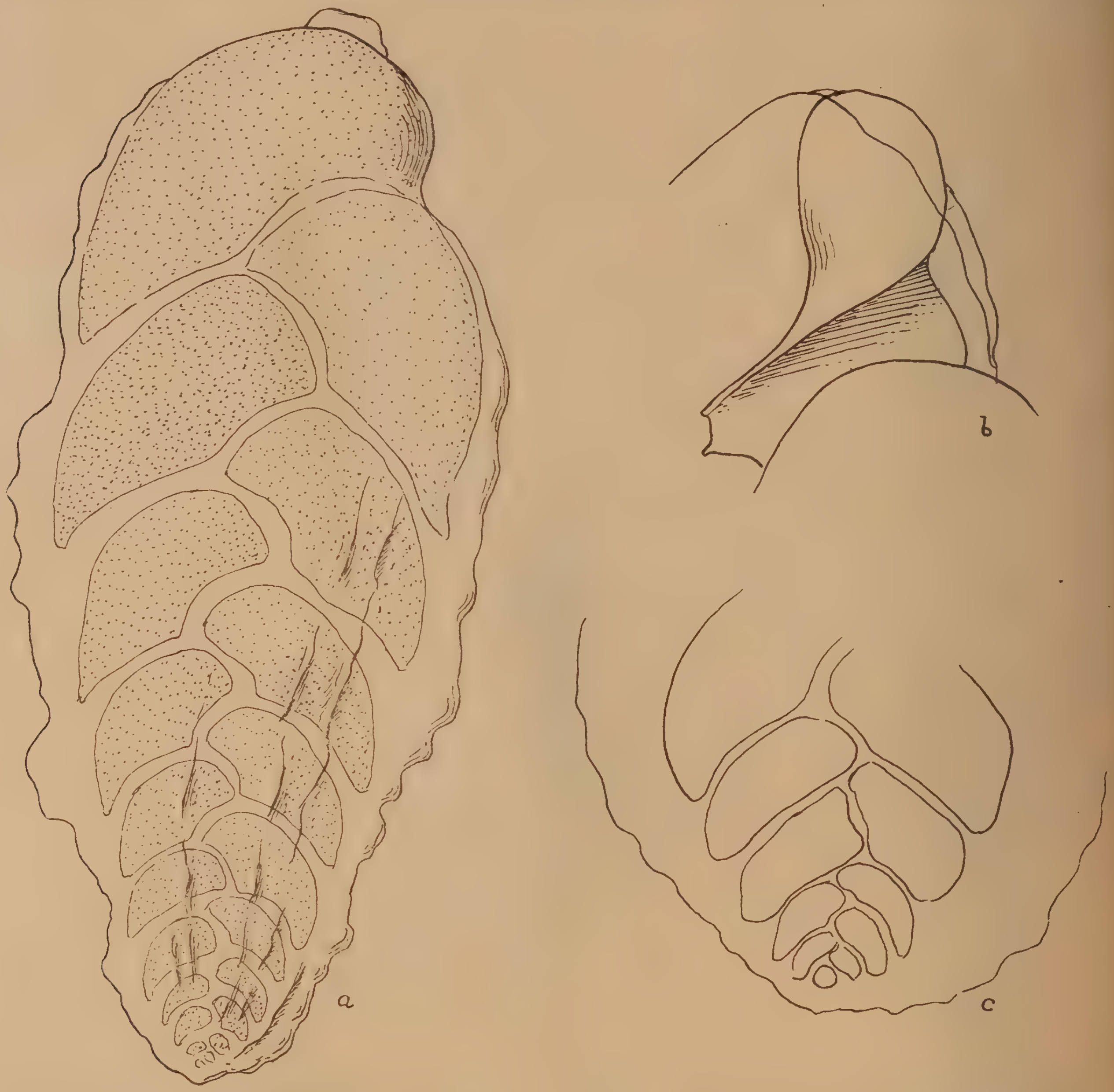


Fig. 57. *Bolivina hantkeniana* Brady. Microspheric form. a, total specimen, × 100; b, toothplate; c, initial part with proloculus; b and c × 480.

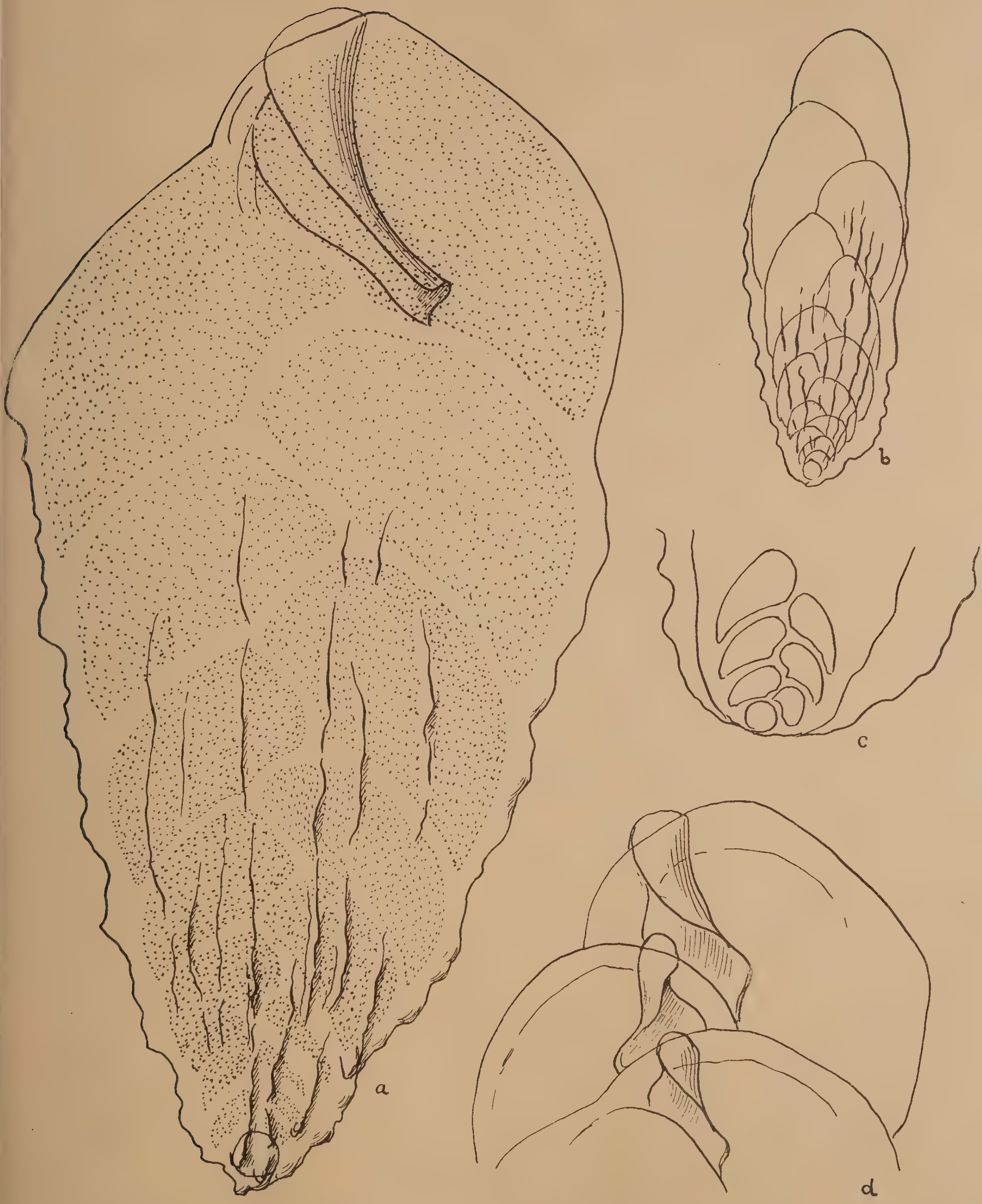


Fig. 58. *Bolivina hantkeniana* Brady. A_1-form. a, total specimen, × 480, with toothplate; b, another specimen, × 100, showing difference in shape with former one; c, initial part of latter specimen, × 480; d, toothplates of latter specimen, × 480.

Length of total microspheric shells up to 0,44 mm, width up to 0,24 mm, length of A₂-generation up to 0,8 mm, width up to 0,3 mm. The species was mentioned by Millet (Journ. Roy. Micr. Soc., 1900, p. 546, pl. 4, fig. 9) from the Malay Archipelago. Cushman found it off southern Japan and in the Philippine Region, mostly at a depth of 220 to 550 fathoms. A single specimen was found by myself at St. 266, 5° 56′ S., 132° 47′ E., depth 595 m, off New Guinea.

It is very probable, that the A_2-form of this species has been called *Loxostoma limbatum* var. *costulatum* (Cushman); it has, however, a toothplate totally different from that of typical *Loxostoma beyrichi* (identical with *L. limbatum*). Only a study of the toothplates of type-specimens can solve this question.

Description:

Test more or less slender, tapering towards the apertural end. In the B and A_1 the margin is surrounded by a more or less broad carina, very hyaline. Walls smooth, except for some more or less developed longitudinal costae, especially in B and A_1, at the initial part. Pores rather fine. Sutures distinct, angled in their middle, oblique. Chambers often very high, especially the later ones. In the A_2 the margin is rounded without carina at all. Aperture a long and narrow opening at the suture, with a protruding tooth without ornamentation. Toothplate very large, with large basal hook and flaring free part.

Length up to more than 1 mm, breadth very variable.

In St. 9° 20′ S., 120° 16′ E., 285 fathoms the species was fairly abundant. But here the state of the generations was found to be of a different kind, as was found in both mentioned stations. For here the A_2-specimens did not show the elongate shape without a keel, but showed the same features as were observed in the other two generations. This points to the suggestion, that there exist two different geographic varieties, the one having an A_2-form without keel, the other with a keel. In all forms, however, the toothplate was quite similar, and this plate once more demonstrated here its independence of outer circumstances.

I give here a statistic scheme of the individuals, found in this station. The A_2-generation, showing the same features as the other two generations here, and not the slender form without keel, has a proloculus measuring from 45 to 95 μ, and the number of chambers is from 7-11. The A_1-generation with proloculus from 12-30 μ, shows 12-17 chambers; the B-generation, proloculus 6-8 μ, possesses 17-23 chambers (Fig. 56).

May be, that the form lacking a keel is a different species, but no specimens with small proloculus have been found, whereas the toothplate is the same one.

Bolivina quadrilatera (Schwager)
(Figs. 59-62)

In his work on the Foraminifera of the Philippine and adjacent seas, Cushman (1921, p. 125) mentions this peculiar species under the name of *Textularia quadrilatera* Schwager. As in his Monograph on the Subfamily *Virgulininae* he does not mention this species, it is obvious, that he believes it to be no real *Bolivina,* though in his Bull. Nat. Mus. No. 71, p. 2, 1911, p. 24-26, he describes fully this species and says: "This species, as has been suggested by various authors, is more like *Bolivina* in some respects than like the other species of *Textularia.*"

It must be regarded as a real *Bolivina,* though the peculiar shape of the chambers is an aberrant one for this family.

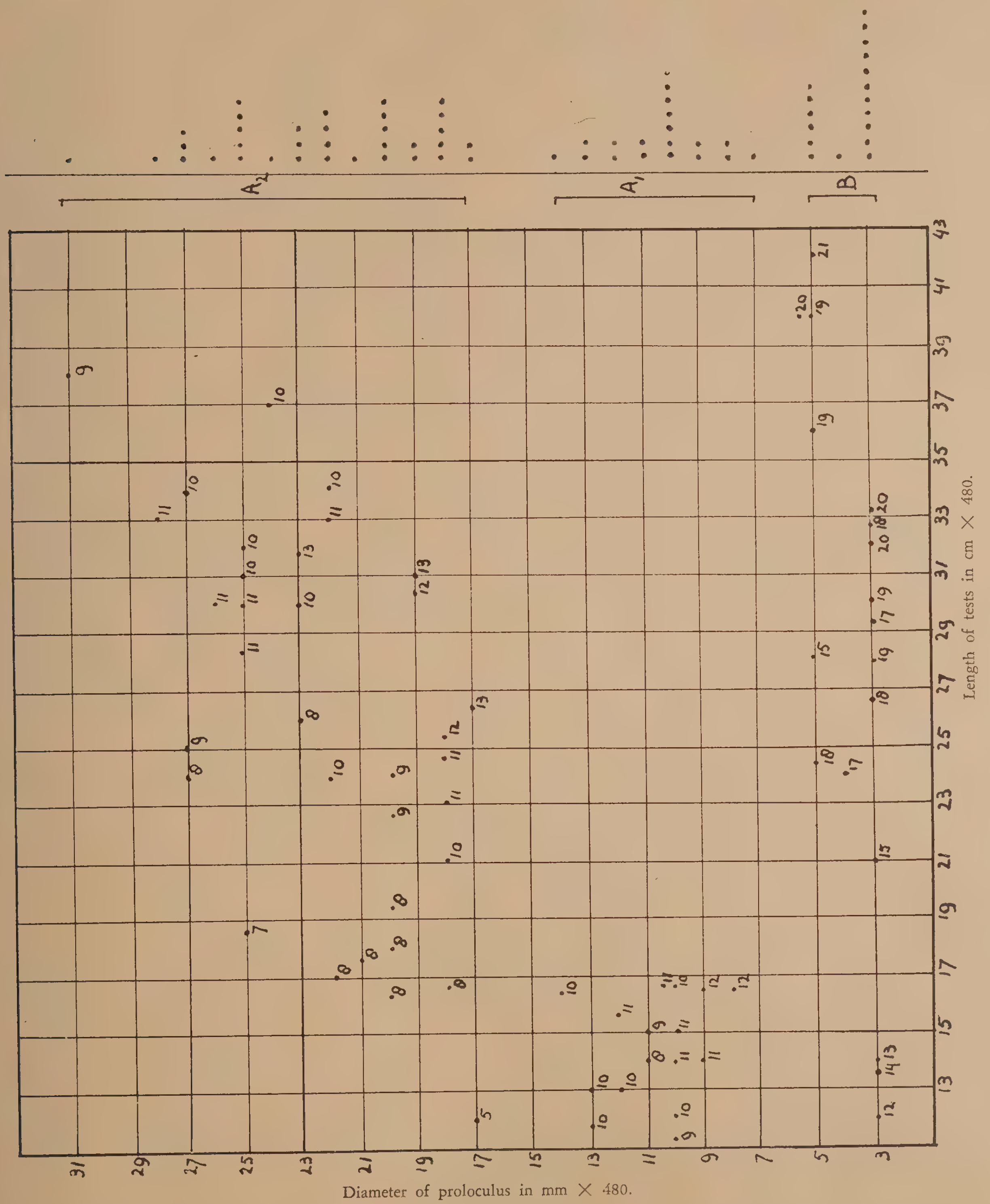


Fig. 59. *Bolivina quadrilatera* (Schwager). Diagram showing relation between length of test and size of proloculus. Three different groups are found, in respect of the prolocular size. In the megalospheric forms the length of test increases when the size of the proloculus increases. One would suggest, that the group A1 here consists of young specimens. This is not the case, as in all gatherings observed, A1-specimens are short.

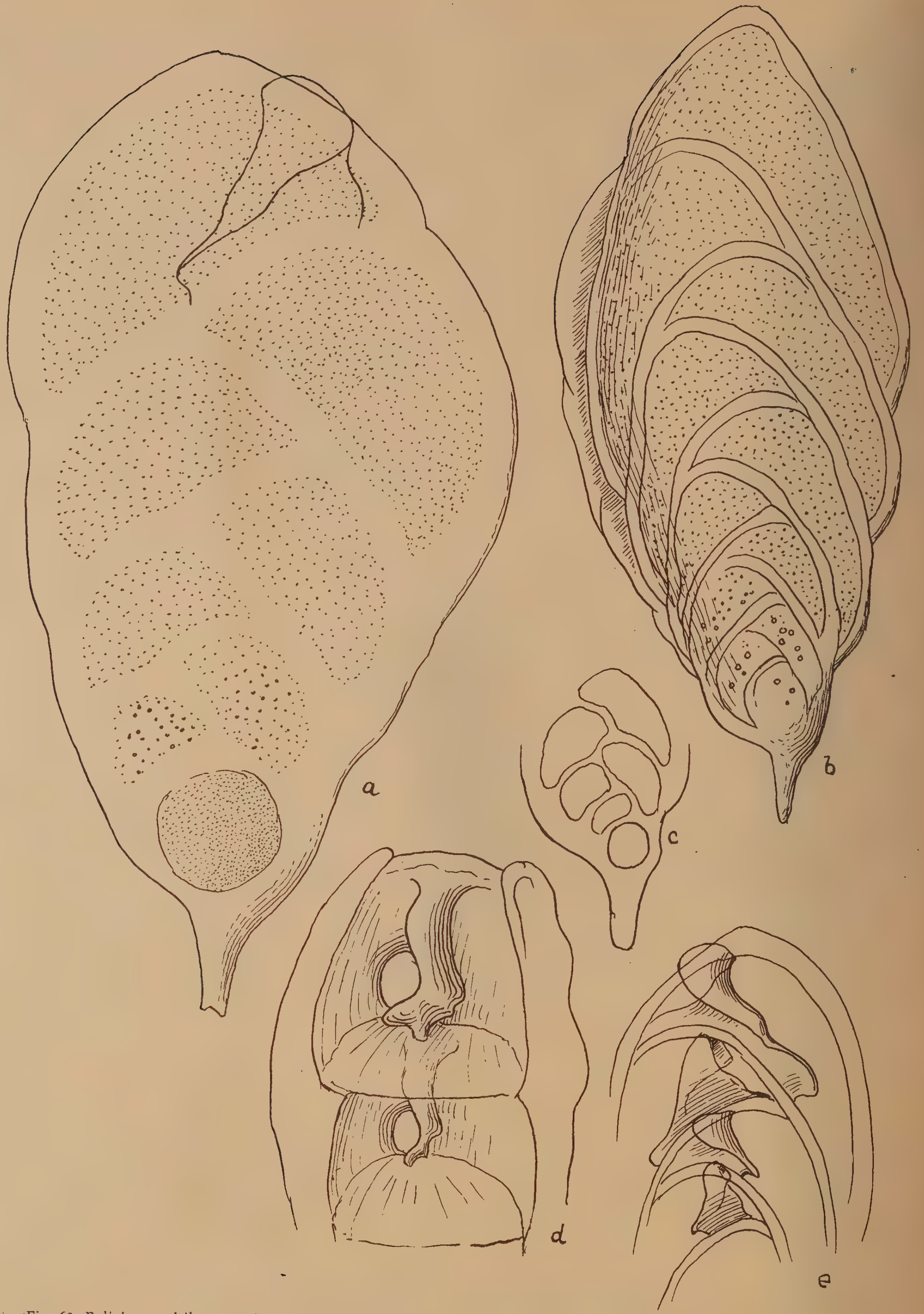


Fig. 60. *Bolivina quadrilatera.* a, A_2-specimen, with toothplate; b, A_1-specimen; c, section through same individual; d, optical section from aside, with toothplates and apertures; e, toothplates of A_1-specimen. × 415.

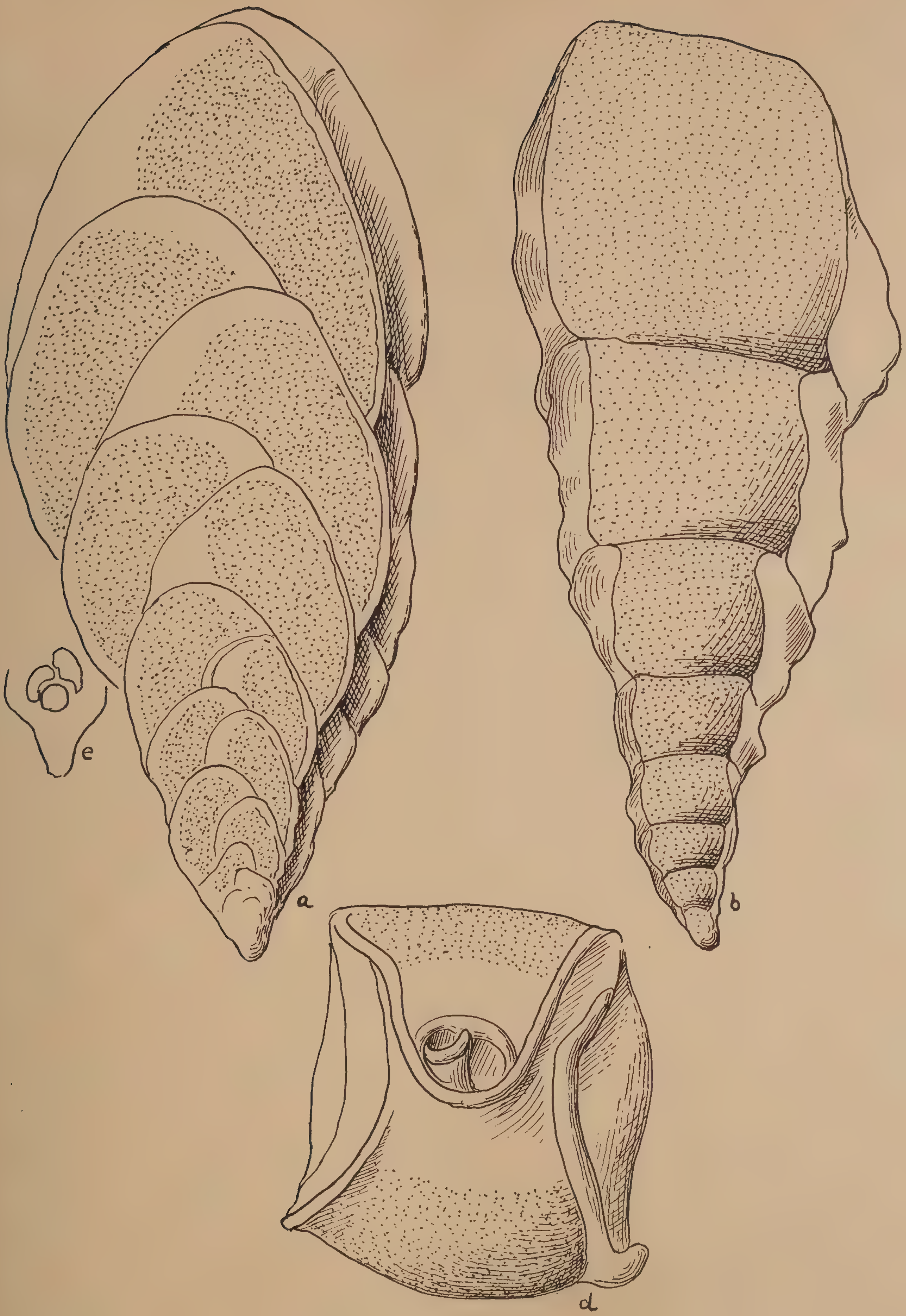


Fig. 61. *Bolivina quadrilatera* (Schwager), Microspheric specimen; a, whole test; b, lateral view; d, apertural view; e, initial chambers. × 415.

The walls are finely perforate, which does not occur in *Textularia*; the aperture is a rounded oval opening at the sutural base of the last-formed chamber, but with the long axis in the length of the chamber, which does not occur in *Textularia.* The aperture shows the peculiar plate with tooth, characteristic for all typical *Bolivinae.* These three characteristics together leave no doubt as to its systematic place: it is a real *Bolivina,* but with two wings at the sides.

Cushman's description of the species (1921) is very correct, except for the description of the generations. He mentions, that the microspheric generation possesses a proloculus ranging from 12 up to 23 μ, whereas the megalospheric form shows a proloculus with a diameter from 76 up to 115 μ. I studied some material from a gathering by the steamer Van Gogh, at 377 fathoms, 2° 17′ S., 99° 27′ E., where the three generations occurred together. The B-form shows the long, tapering form of Cushman's, but it never has a proloculus with a diameter more than 12 μ. The A_1-generation shows the characteristics of the B-form, but the last-formed chambers are somewhat more narrow than the former ones; most specimens show a large spine at the initial end and the well-developed carina at the four angles of the shell. The proloculus ranges from 20 up to 23 μ. The length of the B-form was 417 μ (Cushman mentions even 1,2 mm length) with a breadth of 116 μ; the length of the A_1-generation was about 375 μ with a breadth of about 150 μ. The A_2-generation has already been described by Cushman, with its proloculus ranging from 76 up to 115 μ, its very few chambers, while the sides of the shell are nearly parallel, so that the tapering form does not exist in this generation.

The plate with tooth in the aperture is very conspicuous and large, the tooth however is relatively small, does not protrude in front-view, while the plate at its basal part abruptly comes to an end with a typical hook.

The pores are somewhat larger at the initial part, as secundary chalk has thickened the wall, and the pores are widened therefore.

The species *Bolivina quadrilatera* has been given as type-species for the newly erected genus *Bolivinita* Cushman. As I have pointed out, it is a real *Bolivina,* and has nothing to do with the family of the *Heterohelicinae,* were it was placed by Cushman. The genus *Bolivinita* must be obliterated therefore.

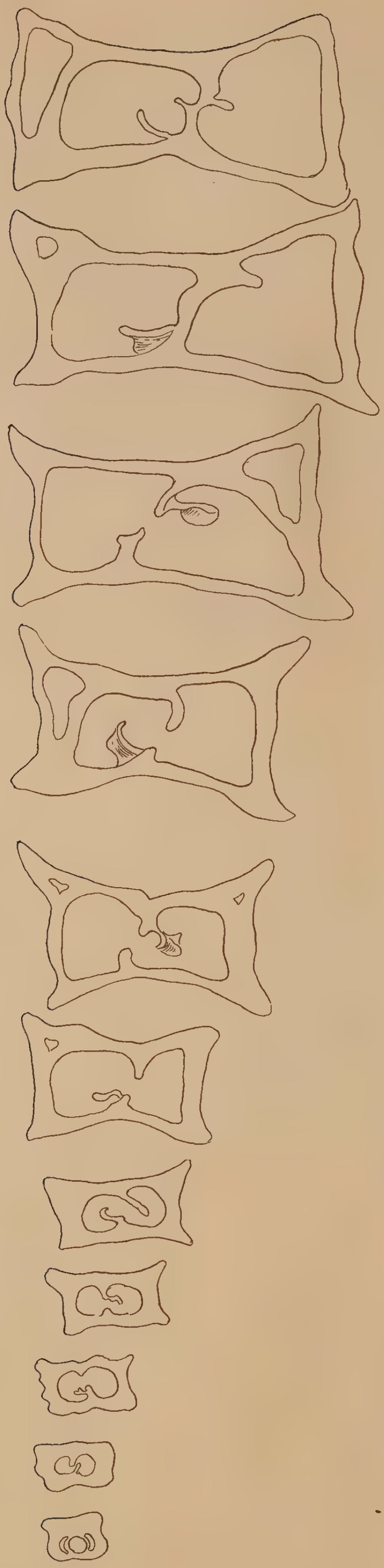


Fig. 62. *Bolivina quadrilatera* (Schwager). Successive transverse sections through a microspheric specimen, showing the alternation of the toothplates and the biserial arrangement of the chambers throughout. × 212.

I studied 44 specimens, found in several parts of the Archipelago, mainly in the neighbourhood of 2° 17′ S. and 99° 27′ E. and near 9° S. and 120° E., and coming from depths between 300 and 800 fathoms. Statiscally it was easy to distinguish the three generations. 11 of them showed to be microspheric. The proloculus was unvariably 6-8 µ diameter, it was directly followed by biserial chambers; this points to real *Bolivina.* The number of these chambers ranged from 15 up to 20. The length of these individuals ranged from 0,3 mm up to 0,70 mm, the breadth 0,20-0,27 mm.

12 specimens showed to be of the A_1-generation, with proloculus ranging from 17 up to 25 µ, with a total number of 10-12 chambers. Length of total shells 0,30-0,35 mm, breadth 0,11-0,18 mm.

21 specimens must be ranged under the A_2-form. 5 of them apparently young ones, with only 8 chambers, and a proloculus of about 40 µ diameter, were relatively small (0,40 mm). The other 16 specimens were larger ones, with proloculus ranging from 37 up to 65 µ, with a length from 0,35 up to 0,78 mm, and a breadth ranging between 0,20 and 0,35 mm. The total number of chambers varied between 9 and 13 chambers in fullgrown specimens. Thus in the A_2-form very large shells show only in average 10 chambers, which gives the impression of few chambers, as mentioned by Cushman.

Sections through the shell showed, that the toothplate was arranged as in all other *Bolivinae,* alternating from chamber to chamber in its position. Here too we have a date pointing to the close relationship of this so-called *Bolivinita* with real *Bolivina.*

So we can be sure, that this *Bolivinita quadrilatera* is nothing but a *Bolivina* with carinate chamberwalls. There is no reason why we should create a new genus only distinguished from the central genus by an ornamentation of the walls. The chambers of *Bolivina* are characterised by the dorsally arranged chambers, the alternating direction of the toothplate accordingly, the situation of the mouth facing towards the middle and near the base of the chamber, the arrangement of the chambers in the microspheric generation directly into biserial rows.

The species is widely distributed all over the Archipelago; it has also been recorded by Millet. Specimens with and without spines are found together, often in the same sample, so that Cushman's suggestion, the Atlantic form might be distinguished from Pacific specimens, doubtless is incorrect.

The genus **Bolivinita** Cushman, exit

I have shown here, that so-called *Bolivinita quadrilatera* (Schwager) is a true *Bolivina,* with a well-developed toothplate and typically sutural aperture, provided with fine pores, and in the microspheric form beginning with a biserial arrangement of the chambers. So this species cannot be grouped in the *Helicohelicinae,* as Cushman did.

There have been grouped together with this species several other species, which are found in the upper-Cretaceous of Europe and America, and there is a gap between these two groups, as in the lower and middle Tertiary no species of this kind is known. Only a single species of "*Bolivinita*" has been described from the Paleocene, "*Bolivinita*" *paleocenica* Brotzen (without giving its inner structure, however).

When studying many specimens of "*Bolivinita*" *eleyi* Cushman from the Upper-Cretaceous of the Netherlands, kindly sent to me by Dr. van Voorthuysen from the Geological Survey of the Netherlands, at once it became clear, that that species did not belong to the same group, to which *"Bolivinita" quadrilatera* belongs. It shows no toothplates, the aperture is not sutural but areal, there are no pores whatever in the walls, in the microspheric form the test begins with a triserial arrangement of the chambers. Dr. Cushman kindly sent to me specimens from Texas and from France of the same species, and they agree in all points with my material from the Netherlands. Moreover I could study a second species, *"Bolivinita" planata* Cushman. This species in many typical characteristics shows those of *Bolivinita eleyi,* so that without doubt it belongs to the same genus.

"Bolivinita" quadrilatera has been chosen by Cushman as the genotype of *Bolivinita.* As those fossil species do not agree in all points, already mentioned, with *"Bolivinita" quadrilatera,* the latter species cannot be regarded at as the genotype of those fossil forms. This fact has already been mentioned by Glaessner, when he says in his "Principles": "The genus was found from Cenomanian to Paleocene, and from Miocene to Recent. This genus is possibly polyphyletic, the Miocene to Recent typical forms being connected by transitional forms with Miocene Indo-Pacific species of *Bolivina.* If morphological differences between the younger and the older groups prove to be of more than specific importance, then the older group alone should be retained in the *Plectofrondiculariinae,* as a new genus." (p. 138, 1945).

Now I found, that *"Bolivinita" planata* and *"Bolivinita" eleyi* have already been figured and named by Ehrenberg in 1854, in his Mikrogeologie. On p. 22 of this work he figured *Bolivinita planata* under the name of *Loxostomum* (pl. 28, fig. 25 and pl. 31, fig. 29); his sections are very carefully drawn and the typical areal apertures and the fine pustules on the walls, which have been mistaken as pores, are clearly seen. *Bolivinita eleyi* has been figured by Ehrenberg as *Loxostomum rostratum* on pl. 27, fig. 20. Both Ehrenberg's species came from Meudon, the same locality, from which Cushman had his European specimens.

The typical feature of the genus *Loxostomum* (*Loxostoma*) is the areal aperture; but later investigators have given the name *Loxostomum* to species, belonging to the *Bolivina*-family, having internal toothplates, as I have shown in this work. So a very large confusion has arisen. Not only two species, belonging to two quite different genera have been thrown together by Cushman under the name of *Bolivinita,* but moreover the genus *Loxostomum* of Ehrenberg has been totally misinterpreted, as Ehrenberg clearly showed, that to his genus belong poreless species, lacking a toothplate (he does not draw any toothplate in his carefully made figures from sections) and having an areal aperture.

Therefore the only method, to unravel this entanglement, due to superficial study of specimens by later authors, would be, that to the genus *Loxostomum* Ehrenberg should belong the cretaceous and paleocene species, showing no toothplate and no pores, with an areal aperture and beginning in the microspheric generation with triserially arranged chambers: *Loxostomum tenuis* Ehrenberg (*Bolivinita planata,* Cushman), *Loxostomum rostratum* (*Bolivinita eleyi* Cushman), *Loxostomum paleocenicum* (Brotzen).

On the other hand, all those species with hyaline walls, provided with fine but distinct pores, with a sutural aperture with a well-developed toothplate, but with carinate flat sides, must be gathered into the genus *Bolivina,* as they show but minor, only specific, differences with that genus.

As for the so-called genus *Loxostoma,* related to real *Bolivina,* with toothplates, and amended as such by modern authors, I have shown in this work, that it is not a typical genus, as very different groups of the genus *Bolivina* have developed descendants with more or less areal apertures at the end of the test. So we may drop this "genus" in the *Bolivinidae,* and call all forms, with areal and with loxostomate apertures, *Bolivina.* I give here a short description of *"Bolivinita" eleyi* from the Cretaceous, to show the differences with *Bolivina.*

"Bolivinita" eleyi (Cushman)
(Figs. 63, 64)

This upper-cretaceous species, of which Dr. van Voorthuysen kindly sent me 34 undamaged specimens, was examined thoroughly. The outer characteristics are sufficiently known from literature, which can be found in Schijfsma, Foraminifera from the Hervian of Southern Limburg; Meded. Geologische Stichting, Ser. C. V. No. 7, 1946, p. 72-73.

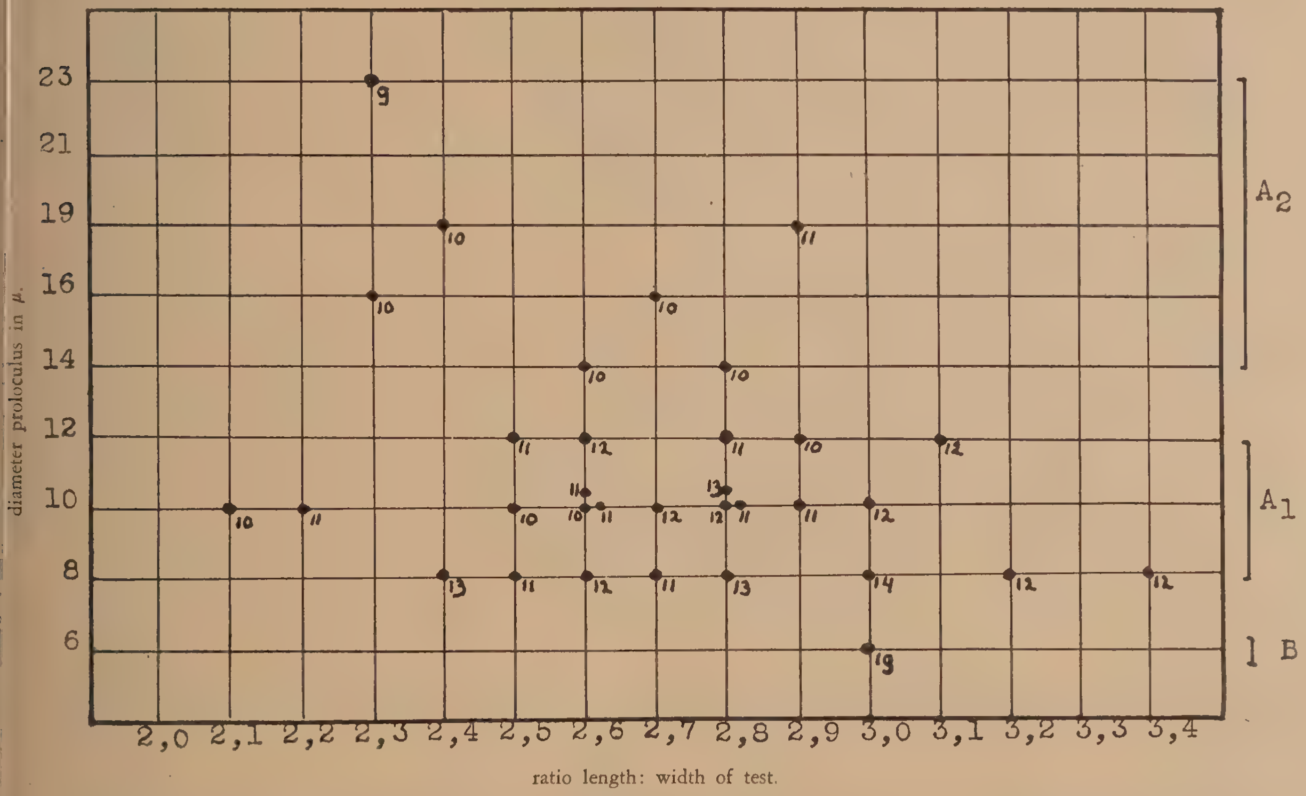


Fig. 63. *Siphogaudryina eleyi* (Cushman), diagram, showing relation between diameter proloculus and ratio between length and width of total test. Added figures: number of chambers.

The walls of the chambers show no pores whatever, but are built up by hyaline chalk-material, in which numerous very fine sand-grains are imbedded; it may be, that these fine sand-grains have been taken for pores. *But pores are lacking.*

Along the shell four alar-like angles run down, which are mainly formed by clear shell-material. In the microspheric form the first part of the shell is rounded in transverse section, and only in the biserial part of the shell the angles are formed, just as in *Siphogaudryina.* In de megalospheric forms the angles are found even at the beginning of the shell.

The shell is elongate, breadth: length as 1 : 3 in the B-generation, as 1 : 2,5 to 1 : 3,2 in the

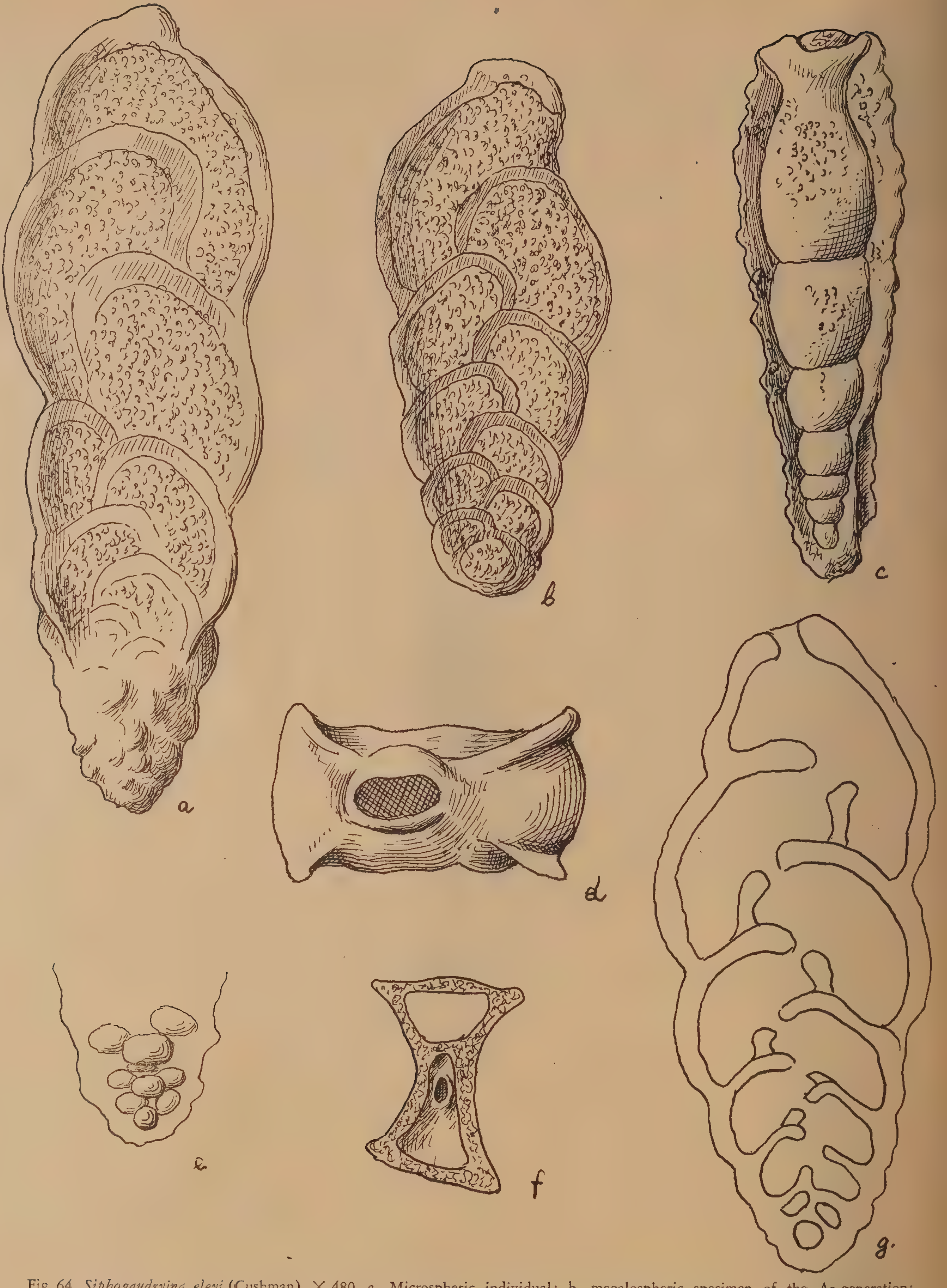


Fig. 64. *Siphogaudryina eleyi* (Cushman), × 480. a, Microspheric individual; b, megalospheric specimen of the A_2-generation; c, A_1-individual seen from aside; d, test from the apertural side; e, first sets of chambers of microspheric specimen; f, section, showing foramen of underlying chamber; g, longitudinal section, showing the interio-areal foramina.

A_1-specimens, and as 1 : 2,4 to 1 : 2,9 in the A_2. Thus A_1- en B-individuals are somewhat more slender than A_2.

Total length: B 0,31, A_1 0,20-0,28 mm, A_2 0,21-0,28 mm. So the length of these specimens is shorter than those, found by Marie and by Brotzen. That indicates, that the specimens, found by Schijfsma and myself from the Upper-Cretaceous in the Netherlands were living in less favourable conditions, than those Marie and Brotzen studied.

The aperture is terminal, or, more accurately spoken, interio-areal. It forms a lengthened oval opening, surrounded by a thickened lip, situated in the breadth of the shell.

The chambers of the first part of the B-generation show three sets of triserially arranged chambers, and then 5½ biserial sets are following. This arrangement points too to the genus *Siphogaudryina,* and not at all to *Bolivina.* The chambers of both A-generations are always biserial.

As the genotype of *Bolivinita* was *"Bolivinita" quadrilatera* (Schwager), and as I could state, that this species was a real *Bolivina,* with its well-developed toothplate, the genus *Bolivinita* (*Bolivinitella*) cannot be placed in the *Heterohelicidae,* as the latter genus lacks the toothplate totally. But, as I showed here, that *Bolivinita eleyi* (Cushman) does not possess pores, but a finely arenaceous shellwall, that it has no toothplate whatever, that the aperture is interio-areal, that the B-form shows the *Gaudryine* arrangement of chambers, it is obvious, that *Bolivinita eleyi* is a real *Siphogaudryina,* showing all characteristics of the sub-genus.

Real *Bolivina quadrilatera* is a species of rather recent and very specialised shape. It cannot have been developed in the Upper-Cretaceous, as in the Cretaceous a whole group of Bolivine forms started. We now have shown, that a typical cretaceous species, hitherto believed to be a *"Bolivinita",* has nothing to do with *Bolivina quadrilatera,* but that it is a *Siphogaudryina.* Thus the genus *Bolivinita* (*Bolivinitella*) must be dropped as not-existing, the genotype being a real *Bolivina,* and other so-called species of the genus belonging to other groups of Foraminifera.

The real name of *Bolivinita eleyi* thus is *Siphogaudryina eleyi* (Cushman).

Loxostoma amygdalaeforme (Brady)
(Fig. 65, 66)

The species was not mentioned by Cushman from the tropical Pacific; he failed in finding it in his rich material. It seems to be rare, as only few specimens were found, all of megalospheric generation. I found it at the following stations:

130° 10′ E., 34° 20′ N., at 60 fathoms.
St. 260; 5° 36′ S., 132° 55′ E., depth 90 m.
St. 204; 4° 20′ S., 122° 58′ E., depth 75-94 m, common.
St 51; Madura-Strait and Molo-Strait, depth 69-91 m.

The records, given by Cushman are all from shallow water, thus the species seems to be a shallow-water-form. This is in agreement with its very thick walls, peculiar for the genus.

In the earlier chambers the very coarse pores are always arranged into longitudinal lines. Between those lines, the wall here and there is thickened into costae which often anastomose and give the shell a peculiar shape. In the later chambers of typical loxostomous shape, with aperture terminal, the pores are more irregularly arranged, and longitudinal costae are not present. In some specimens, from St. 204, the costae are thinner and somewhat more numerous; these specimens had a comparatively small proloculus (B?). Here the costae were also present in the typical loxostome chambers. These individuals were larger (about 1 mm), while those with thick costae and the endchambers without costae showed a larger proloculus (25 μ diameter) and were of smaller size (0,8-0,9 mm).

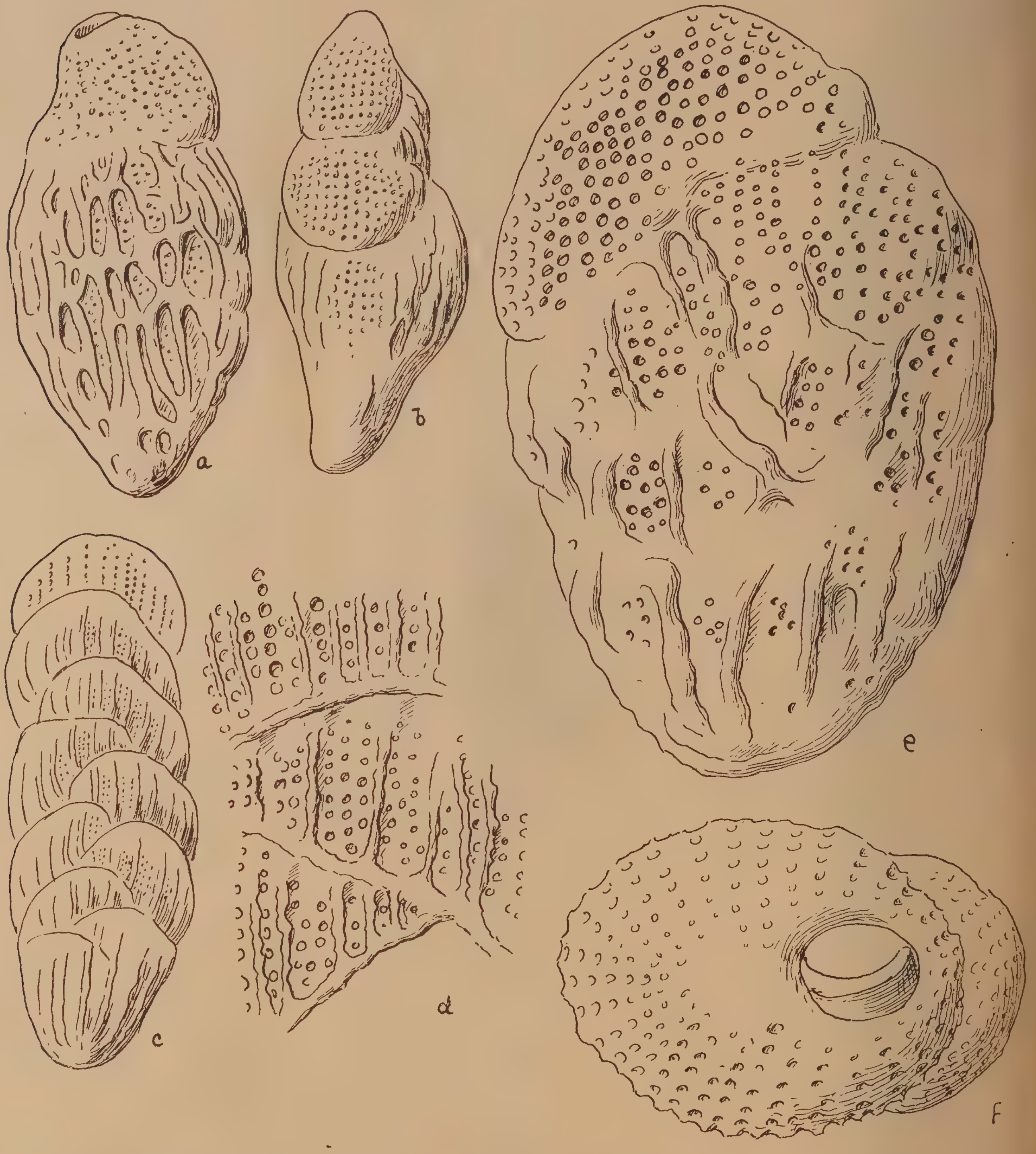


Fig. 65. *Loxostoma amygdalaeforme* (Brady). a, and b, front- and sideview; × 90; c, specimen with uniserial chambers; × 90; d, part of same individual, × 450; e and f, megalospheric specimen, sideview and apertural view, × 450.

The earlier chambers are in transverse section nearly globular, but in later chambers the transverse section becomes oval.

The typical bolivine chambers have an aperture which does not reach the suture of the chamber, and shows a typical bolivine toothplate, with broad folded free tooth, somewhat protruding

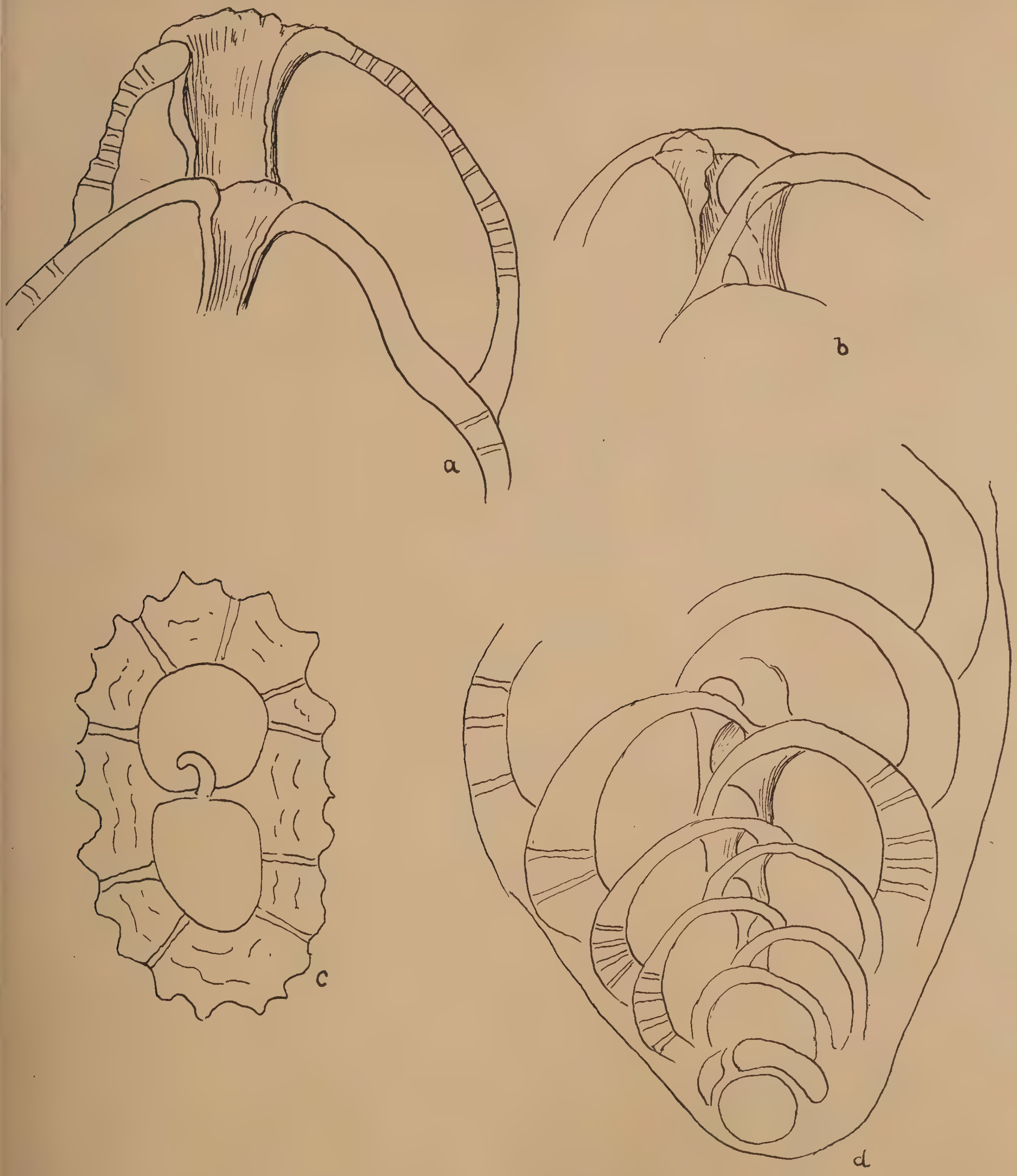


Fig. 66. *Loxostoma amygdalaeforme* (Brady). a, section through uniserial chambers, showing toothplates; b, section through biserial chambers, with toothplates; c, transverse section; d, longitudinal section with megalospheric proloculus. × 480.

from the mouth. But the loxostome chambers possess a nearly flat toothplate, without a typical folded tooth; it attaches itself at one of the sides of the oval aperture, which side always is the more protruding one.

Thus the toothplate does not altogether resemble that of typical *Loxostoma.* This fact, together with the very coarse pores, lead to the suggestion, that *Loxostoma amygdalaeforme* is not a typical *Loxostoma,* but must be placed in the neighbourhood of *Rectobolivina dimorphis,* which shows the same thick walls, coarse pores and very typical toothplate in its first chambers, whereas in the uniserial ones the toothplate of the two species is likewise the same, being a somewhat flat plate with two lightly folded borders. Brady records it from the North coast of New Guinea, depth 1070 fathoms and from Torres Strait, 155 fathoms; Cushman mentions it from Sulu Sea, off Western Mindanao, 38 fathoms; he found it in his rich material from the Tropic Pacific.

Description of the species:

Test depressed fusiform, about twice as long as broad, in the early portion only slightly depressed, more strongly in the later chambers. Periphery broadly rounded, greatest breadth about the middle. Chambers hardly distinguishable from each other, as the longitudinal irregular costae fuse with the somewhat elevated sutures to an irregular network of ridges. Between those ridges the pores are situated in longitudinal rows, even in the last-formed chamber, from which the surface mostly is not costate. Walls very thick, not hyaline, and yellowish in colour. Pores coarse and distinct in the later chambers. Aperture in the adult not totally terminal, a rounded oval opening, devided in two nearly equal parts by a curved tooth, and with a poreless rim.

Length up to 1 mm, breadth up to 0,35 mm.

The typical yellowish colour of the shell, especially in transmitted light, is characteristic for the whole group, *L. amygdalaeforme, R. nov. spec., Rect. dimorpha, L. karrerianum.*

Rectobolivina nov. spec.
(Fig. 67)

Two megalospheric specimens were found in a gathering 10° 00′ S., 123° 19′ E., from a depth of 453 fathoms. They seem to be extremely rare, but are very conspicuous. The beginning of the tests shows rather coarse pores only at the initial side of the chambers, while the apertural end is smooth. In the uniserial chambers the whole chamber is covered with those pores, which are somewhat smaller than those of *Rectobolivina dimorpha.* At the initial end of each chamber the walls are thickened, but the pores are spared out, thus the total building giving rise to a fine dentation, directed towards the initial end. It is something as is found in *Rectobolivina dimorpha* on a much larger scale. The end-chambers in one outgrown specimen narrows towards the phyaline lip, as in *R. dimorpha.* The toothplate in the uniserial chambers shows the typical structure of those in *R. dimorpha* and *R. columellaris,* alternating in situation in each next chamber. The biserial part begins with a proloculus with a diameter of about 17 μ; it is followed by 8 biserial chambers. The biserial part is somewhat compressed, but the uniserial part is rounded. The aperture is a round terminal opening. The chambers are not high. Length of one specimen 0,32 mm, of the other one 0, 43 mm. The shorter specimen shows 5 uniserial chambers, while the longer one has 6 of them.

There is some possibility, that this form is identical with Liebus' *Bifarina adelae,* from the Miocene. (See Cushman, 1937, l.c., pl. 22, fig. 28).

As no microspheric specimens were found, a specific name should not yet be given to this species, in case it shows to be not identical with *Bifarina adelae* Liebus. The description of the megalospheric form is: Test very much elongate, compressed in the early portion, which is totally

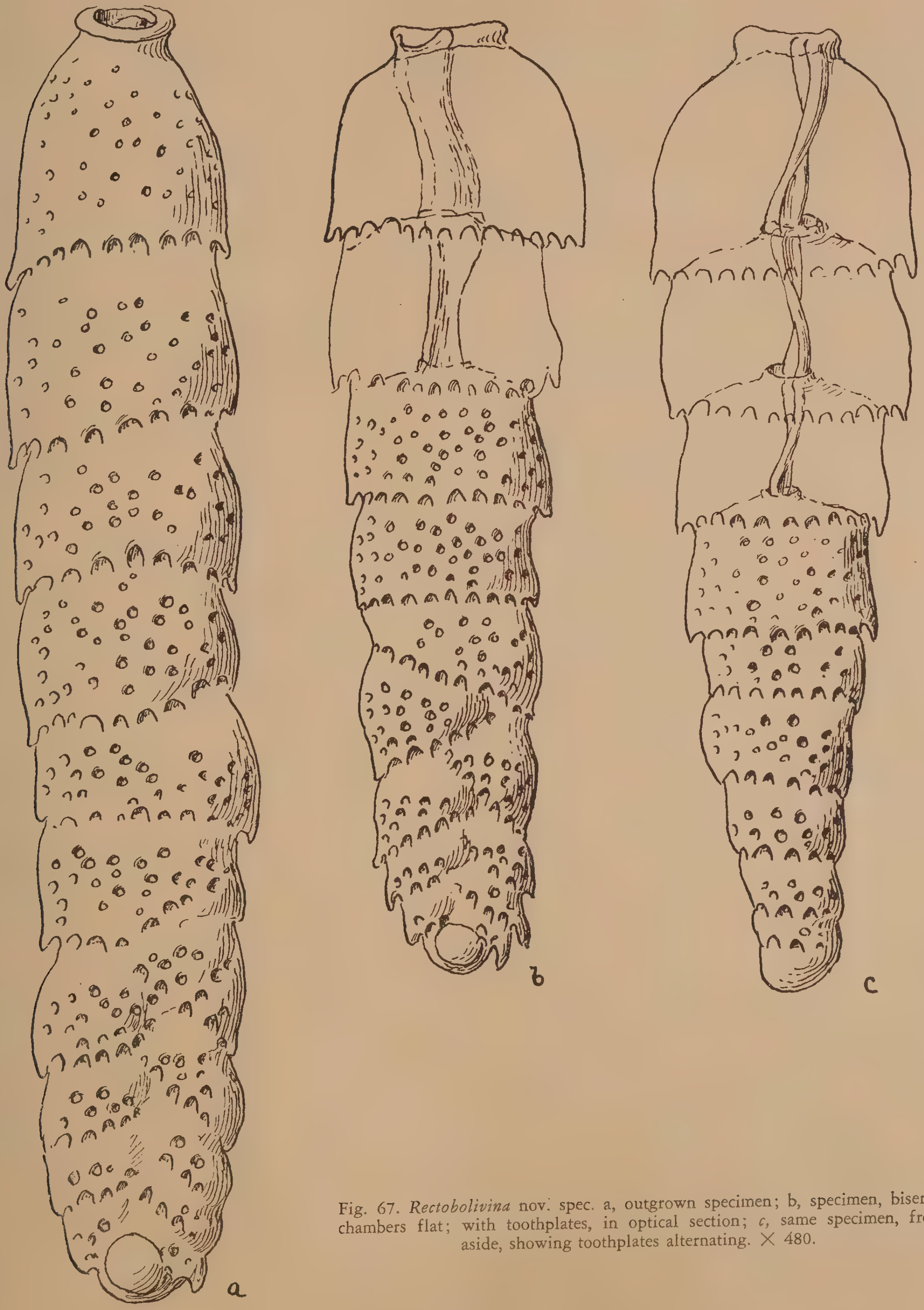


Fig. 67. *Rectobolivina* nov. spec. a, outgrown specimen; b, specimen, biserial chambers flat; with toothplates, in optical section; *c*, same specimen, from aside, showing toothplates alternating. × 480.

bolivine. In adult specimens the later chambers increase very much in height, and are somewhat more slender than the foregoing ones, so that the broadest portion of the test is not at the end. Chambers very distinct with many bridges at the sutures, directed backward. They are situated between the pores at the suture. Early portion with at least 8 biserial chambers which are somewhat inflated, equally to the later ones. Pores coarse, walls yellowish. Aperture a rounded opening, terminal, with very short neck and phyaline lip, with a rounded tooth, not projecting from the aperture. Toothplate somewhat curved, alternating in the successive chambers. Length up to 0,43 mm, breadth 0,08 mm.

Rectobolivina dimorpha (Parker et Jones)
(Figs. 68-71)

This species was described by Parker and Jones as an *Uvigerina,* Brady mentions it in the Challenger-Report as *Sagrina dimorpha,* Cushman as *Siphogenerina dimorpha.* He found it in several parts of the Pacific, viz. the Philippines, China Sea, Gulf of Tomini (Celebes), and Macassar Strait. I discovered it in some abundance in a gathering by H. M. Steamer Van Gogh, at a depth of 377 fathoms, 2° 17′ S., 99° 27′ E, temperature 8,5° C. This is the same temperature, found in the Macassar Strait by Cushman.

The species was moreover found at the stations:

st. 49a, 8°, 23′ S., 119°, 4′ E., depth 69 m
st. 262, 5P, 53′ S., 132°, 48′ E., depth 560 m

Cushman records it under the name of var. *pacifica* from several stations North of the Archipelago, while Koch found it in the late Tertiary of Java.

Statistic measurements showed three or perhaps four groups. First there are some young specimens, with only 2 or 3 uniserial chambers. They cannot be taken into consideration as to the generations, but here they are of some importance, as the very small number of uniserial chambers in this species gives rise to a domination of the young ones, as the latter are not much smaller in total size than the adult forms. These young specimens especially are found to be of the A_2-form, as this form always shows the tendency to form few chambers. Here they may be even adult specimens.

B-generation. The generation begins with a biserial portion, with inflated chambers, but this inflation is not seen outerly, as secondary chalk thickens the walls in this part of the shell. The secondary chalk gives the initial end a bluntly rounded shape. The rest of the shell, the uniserial part, very slowly increases in breadth and the sutures between the chambers are scarcely seen, while the typical retral processes of the other two generations are lacking here nearly totally. Only in the initial end here and there indications of such processes are found. The processes are totally due to an outgrowth of the secundary chalk-layers of the walls, while these chalky thickenings are avoiding the large pores at the sutures, thus giving rise to those processes. But these processes are built by the chambers as in *Bolivina subreticulata.* The initial part, the biserial one, in the B-form is built up by 5-7 chambers, except the proloculus, which measures 6-10 μ diameter. As those chambers are found in a single layer, but as their inflated form may cause the error, that they are situated in rows of three, I will point out here that sections made clear, that they are situated absolutely in a single plan, so that the genus, to which this species belongs, cannot be that of *Siphogenerina.* In those bolivine

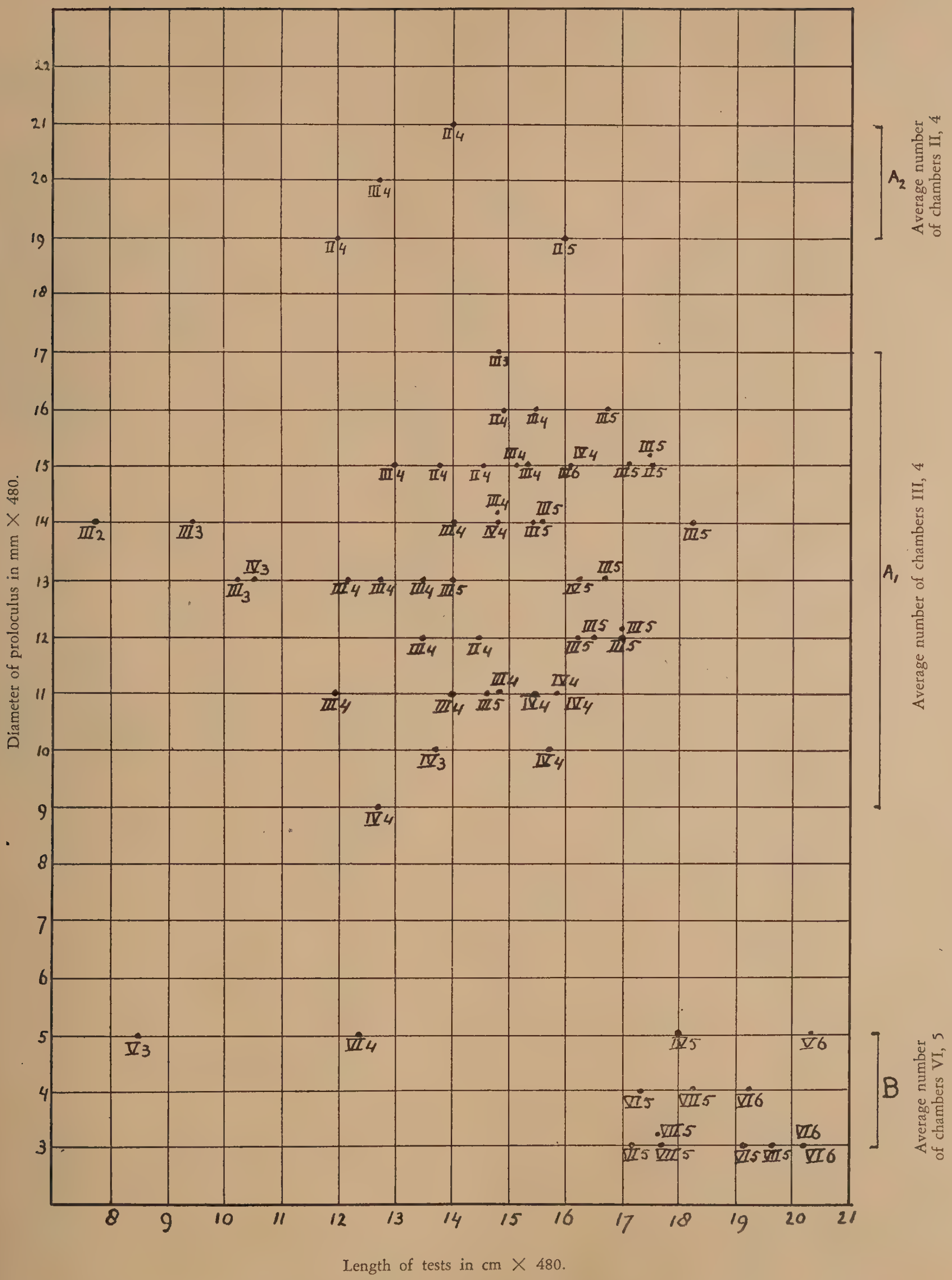


Fig. 68. *Rectobolivina dimorpha* (Parker et Jones). Diagram of relation between size of proloculus and length of tests. The roman figure indicates the number of biserial chambers, the arabic one that of the uniserial chambers.

chambers a small toothplate also was found, giving rise to a curled tooth in the aperture. The walls of this biserial initial part are very thick, especially the outer walls. The uniserial part in the adult has 5 or 6 chambers. The aperture is in the centre of the endface of those chambers, and is oval in form. It has a short neck and a phyaline lip, provided with a curled tooth which ends underneath the aperture.

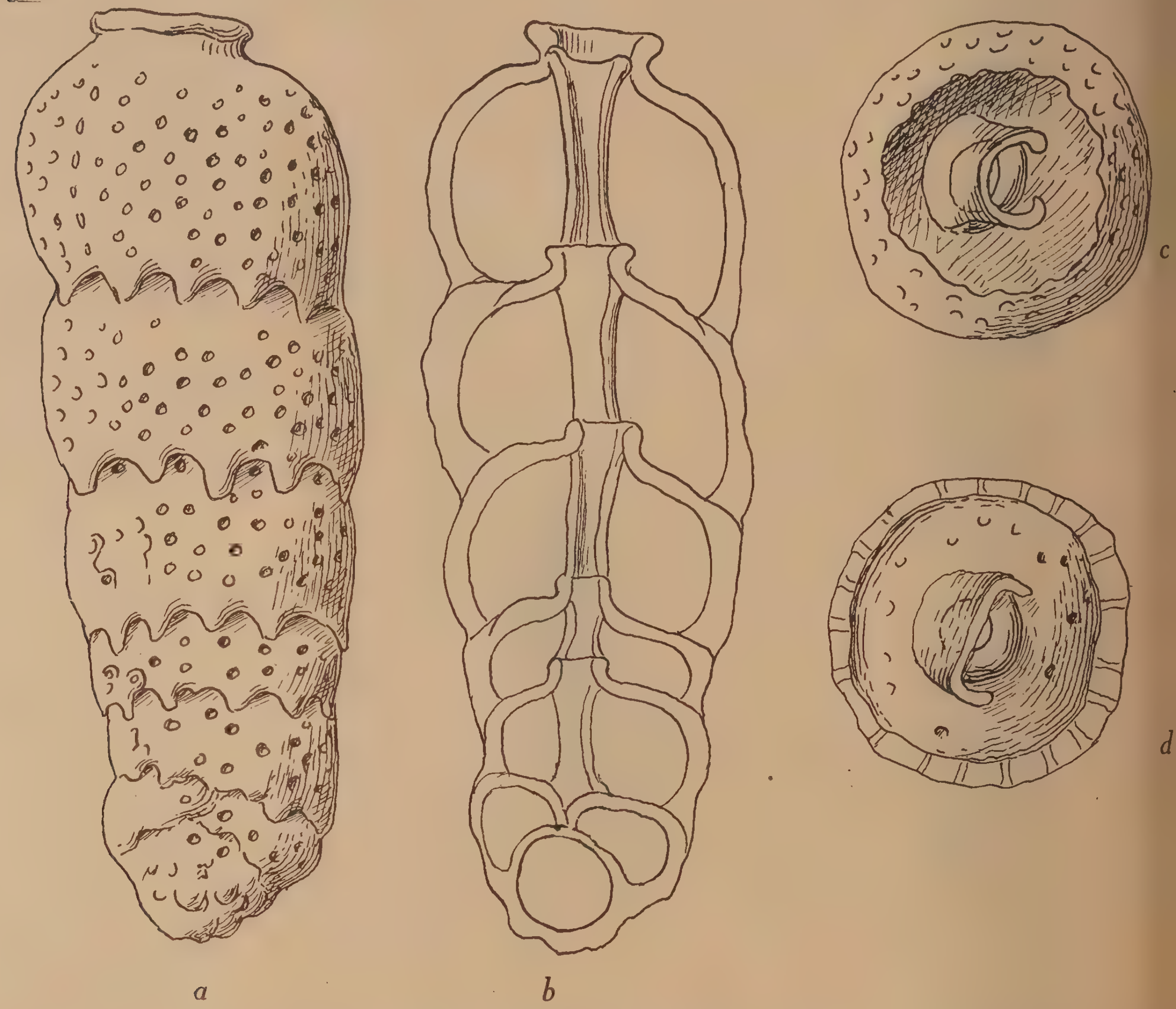


Fig. 69. *Rectobolivina dimorpha* (Parker et Jones). a, A_2-form; b, section, with toothplates; c, chamber partly ground down, with toothplate; d, same chamber, transverse section; × 480.

Length of the outgrown shell up to 0,43 mm.

A_1-generation. This generation is relatively common in the material, as 44 specimens on a total of 62 were found. The shell is large and relatively slender, with a bluntly rounded initial end, very slowly increasing in breadth. The chambers are separated outwardly by excavations, mentioned already above, the portions between extending backwards and bridging over the suture. The walls are, especially in the initial part, thinner than in the B-form, the pores somewhat smaller too. The sutures are more distinct, the chambers a little more inflated.

The initial end is formed by a proloculus with a diameter of 17-35 μ. It is followed by 3-4 biserial chambers, and then 5-6 uniserial chambers are added in the adult. The aperture is somewhat smaller than that of the B-form, shows the same characteristics. Length of the shell from 0,156 mm up to 0,5 mm.

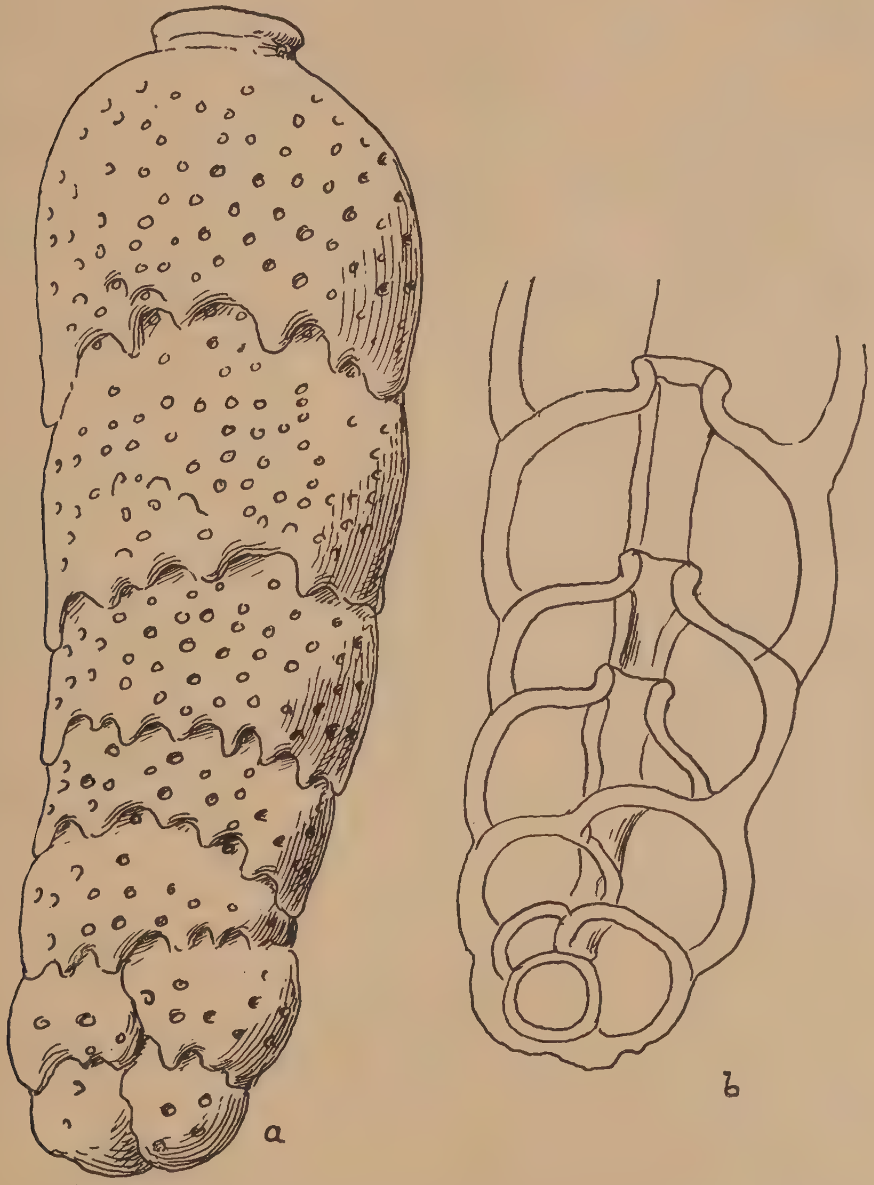


Fig. 70. *Rectobolivina dimorpha* (Parker et Jones). A_1-form, a, total shell; b, section with toothplates. × 480.

A_2-generation. In this generation the proloculus forms the end of the shell, while in the other two forms the next chambers are situated aside of the proloculus and in this way also form the initial end. It is therefore that the initial end is somewhat sharper than in the other generations. The excavated sutures are distinct, the uniserial chambers somewhat inflated.

The proloculus measures in this generation from 40 up to 44 μ, and is followed by 2 biserial chambers in most individuals. The 4-5 uniserial ones are added.

In transverse and longitudinal sections the plate of the aperture was studied. It was found to originate from the dorsal or ventral side of the apertures, when these are seen in such a way, that the biserial chambers are seen in a single horizontal plane. Thus this arrangement is the same as in all *Bolivinae* and in *Rectobolivina.* But in *Rectobolivina columellaris* it was contorted, so that it reaches the next aperture at an opposite side as where it originates. But in this species it runs straight ahead, does not become flattened and reaches the next aperture in the same curved way, thus

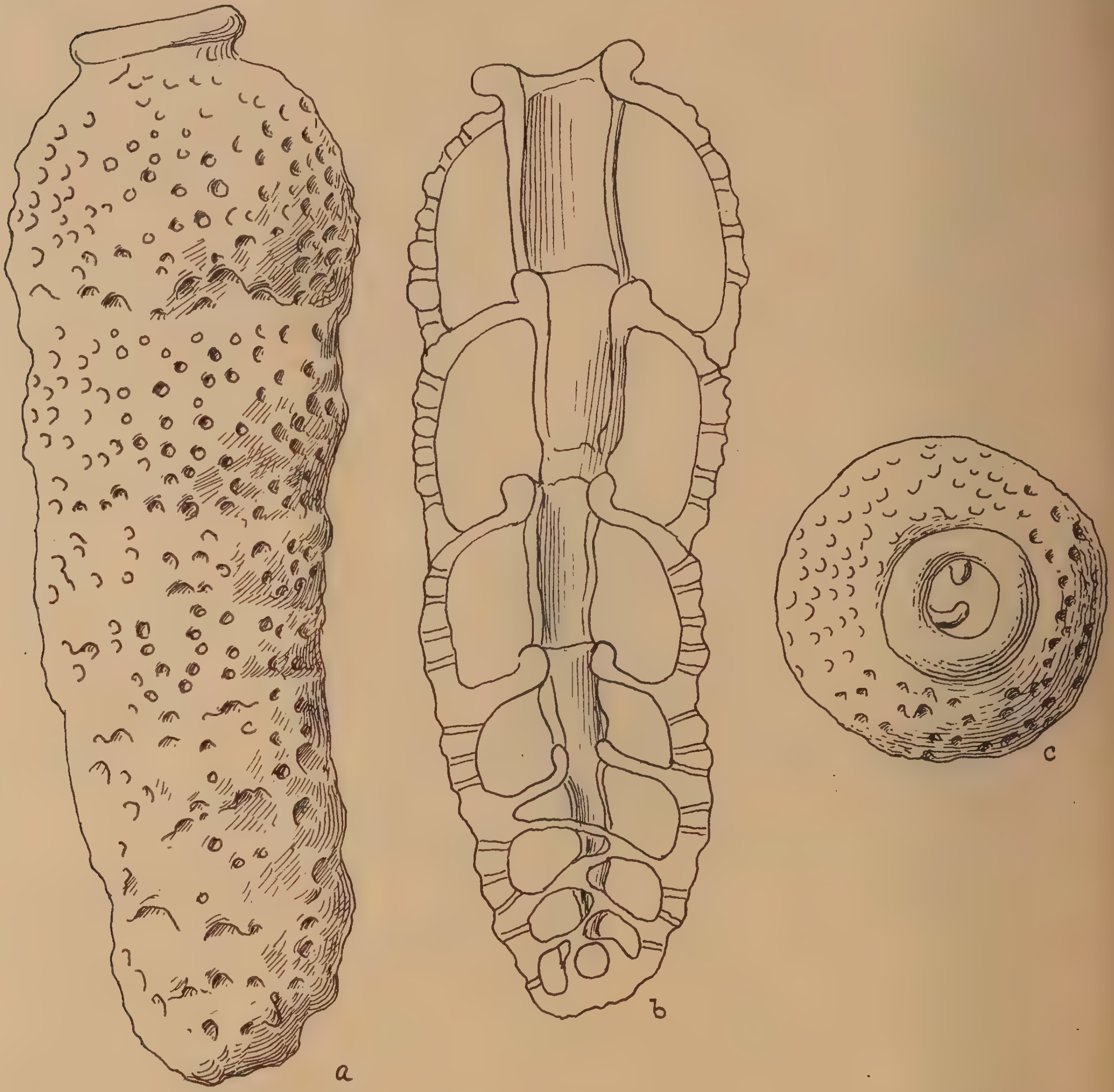


Fig. 71. *Rectobolivina dimorpha* (Parker et Jones). B-form. a, total shell; b, section with toothplates; c, apertural view. × 450.

forming nearly half a circle, the ends of which are somewhat thicker than the middle part of the plate. Thus underneath the aperture these two ends are seen as two short thickened teeth.

The biserial arrangement of the first formed chambers, with their typical alternating bolivine apertural plate, the uniserial development of the next chambers, with their alternating apertural plate, are both characteristics of the genus *Rectobolivina.* Several species of *Bolivina* show a phyaline lip with neck; this is not a difference giving rise to a separate genus. In some species of *Bolivina* the pores are rather fine, in others they are larger. This characteristic too does not give rise to a separation into two genera. Thus I am sure, that our species belongs to the genus *Rectobolivina.* It has to be called *Rectobolivina dimorpha* (Parker et Jones).

There seems to be no difference between the species, found in the Atlantic and that in the Pacific. Höglund (1947, l.c., p. 284-286) described it from Koster Channel; he too came to this conclusion, when he says: "However, I must stress the fact that the Koster specimens (and also the Bukken Fjord specimens just referred to) agree extremely well with Cushman's description and figures of the variety *pacifica* but less well with those of the main form". The measures, given by Höglund (length 0,23-0,53 mm; breadth 0,10-0,18 mm; number of biserial chambers 3-6; number of uniserial chambers 1-6; diameter of proloculus 30-50 μ) agree in all respects with those, given here for the megalospheric generations.

It may be, that the species, here mentioned as *R. nov. spec.* has caused the confusion which has lead to the suggestion, that in the Pacific there exists a variety differing from that in the Atlantic.

Description:

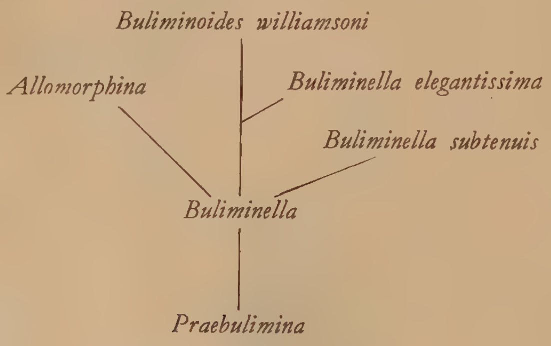
Test nearly cylindrical, except for the initial part, which may be somewhat compressed, very slightly tapering from the more or less rounded initial end to the greatest width near the apertural end. Chambers few, broader than high, slightly inflated. Sutures distinct in the megalospheric forms, not so in the microspheric, the basal portion of each chamber tending to form sutural bridges at regular intervals. Walls with coarse pores with a diameter of about 4 μ, very regularly placed, in the older chambers pitted, as the walls have thickened; colour always yellowish. Aperture circular or rounded oval, terminal, at the end of a short neck, with a distinct phyaline lip. Length up to 0,50 mm.

Family *Buliminellidae*

This family is very closely related to the genus *Praebulimina* from the Cretaceous. The only typical difference is the higher development of the toothplate, which, in typical *Praebulimina* resembles very much that of *Cassidella,* whereas in the *Buliminellidae* this plate has developed into an external part, forming the larger part of the, always poreless, apertural face. In forms from the Cretaceous, kindly sent to me by Dr. Brotzen and Dr. van Voorthuysen, the aperture is elongate, and the apertural face smooth; they are scarcely differing from real *Praebulimina,* except for the fact, that the typical triserial arrangement of the chambers does not exist, the chambers being situated in a close coil. In later forms, such as *Buliminella madagascariensis,* the apertural plate has a peculiar radiate lining, which is formed by the dentated border of the toothplate which forms here the whole apertural face. In some forms the test is compressed, and only two chambers form a whorl, as in *Buliminella subtenuis,* while in other forms the test is covered by longitudinal costae, while the central walls of the chambers are more or less absorbed, so that a central tubular hollow is found, which is connected with the aperture, formed partially by the striate toothplate, partially by the adjacent chambers. These structural characteristics are found in *Buliminoides.*

The *Buliminellidae* thus must have derived from *Praebulimina* or vice versa. The typical fine pores, the smooth surface, the thickened walls and the primitive toothplate in the older forms show this close relation. But, whereas in *Praebulimina* the arrangement of the chambers shows a typical triserial arrangement, the chambers of *Buliminella* are arranged in coils, which often show at the beginning more than three chambers. The genus *Buliminella* itself is found from the Cretaceous on, and, in the Upper Cretaceous reaches its highest development. *Buliminoides* is found only in recent and late-tertiary deposits, as well as in Pacific as in West-Indian regions. All species known from recent deposits are rare ones.

The genus *Buliminoides* is a late offspring of the *Buliminella*-group, and shows typical characteristics of some Rotaline forms; but its typical late development and its specialisation makes it clear, that no other offsprings from this genus can be found in the Rotaline group.



The figure shows the relations between the different groups of the *Buliminellidae.* In *Buliminella* the toothplate on one hand points to the simple one, found in *Cassidella,* but its higher development, its attached part being much broader and giving rise to a larger part of the apertural face, points directly to the *Ceratobuliminidae,* in which group the toothplate attains its highest development, but in the same line as in *Buliminella,* the attached part being broad and giving rise to a distinct suture with the outer chamberwall, whereas the free part is likewise folded with distinct teeth and outgrown parts, while the attached part in many *Ceratobuliminidae* forms parts of the outer chamberwall (*Lamarckina, Marginolamellidae, Laticarinina,* etc.). Moreover in *Buliminella* the coiled arrangement of the chambers becomes dominant, the coil in the *Ceratobulimina* being only lower than in *Buliminella.*

Geographic distribution

Buliminella spicata. Western part. Australia, Fiji, etc.

Buliminella elegantissima. Both areas? Rare, in the Philippines. Australia, Coast of Peru.

Buliminoides williamsoni. Mainly western part, but also south of Flores. Is not mentioned by Cushman from the Philippines, but it is from Fiji, etc. (1942).

Buliminella subtenuis. South of Sumatra, western part. Fiji, Samoa.

It seems, that all species of *Buliminellidae* are widely spread over the area, though always rare. This may be due to the ancient character of the *Buliminellidae.*

On some fossil species of *Buliminella* (Figs. 72-76)

I studied several fossil species of *Buliminella,* viz. *B. ovula* (Reuss) from the Upper-Turonian of Lobosch and *B. spec.* from the middle Turonian of Lobosch (Böhmen), kindly sent by Dr. Brotzen. From *B. ovula* I had 17 specimens, 8 being of the A_1 or B-generation, the other specimens being megalospheric (A_2). The B-specimens had a proloculus of 6-8 μ diameter, whereas the megalospheric specimens showed a diameter of proloculus ranging from 25-40 μ. The material was not large enough, to trace trimorphism.

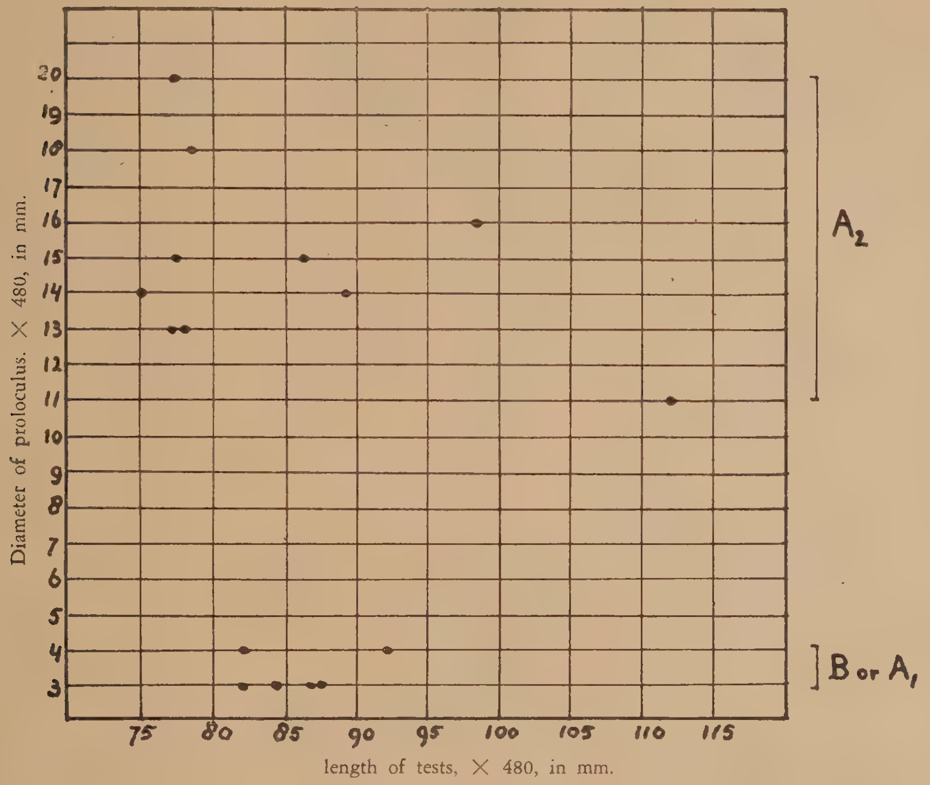


Fig. 72. *Buliminella ovula* (Reuss) from the Turonian of Lobosch. Relation between length of tests and size of proloculus.

In the microspheric form the proloculus is followed by a whorl of 4 chambers, and the other whorls maintain that number up to the last-formed one, which shows only three chambers.

The walls possess very fine pores, very regularly spread over the surface.

In the megalospheric generation the much larger proloculus is followed by whorls, containing likewise four chambers. In the other species of *Buliminella,* from Lobosch, the number of chambers in a whorl likewise was always four, except for the last-formed whorl, which in a microspheric specimen had three chambers.

The toothplate of both species has been studied on longitudinal and transverse sections. It is of a simple type, beginning at the upper border of the former aperture, running through the axial part of the chamber with the attached part much rounded and bulky, while the free folded part becomes broad and somewhat flaring and is attached to the upper border of the aperture,

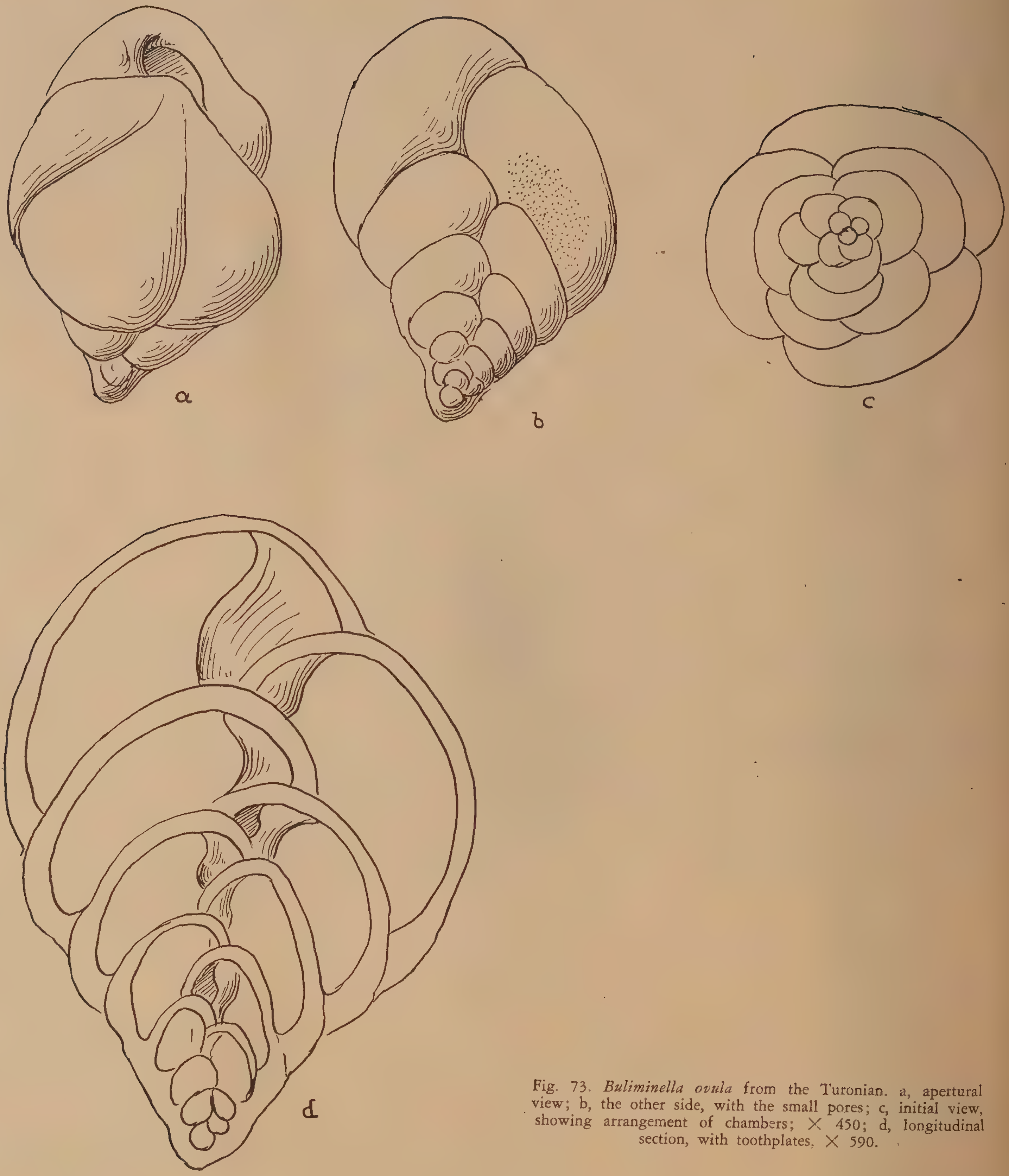


Fig. 73. *Buliminella ovula* from the Turonian. a, apertural view; b, the other side, with the small pores; c, initial view, showing arrangement of chambers; × 450; d, longitudinal section, with toothplates, × 590.

forming this border totally. Thus one can, entering the aperture, reach the inner part of the chamber by emerging under the free border of the folded free part only.

Thus this toothplate shows in principle the structure of those, found in *Cassidella* and its allies. This character, together with the very fine pores, points to a close relationship between *Cassidella* and fossil *Buliminella.* The attached part of the toothplate is always the proximal part of it; this is worth mentioning, as it may be, that in reality in all other groups, derived from *Buliminella* or allied forms, the attached part of the toothplate is the proximal part, thus giving

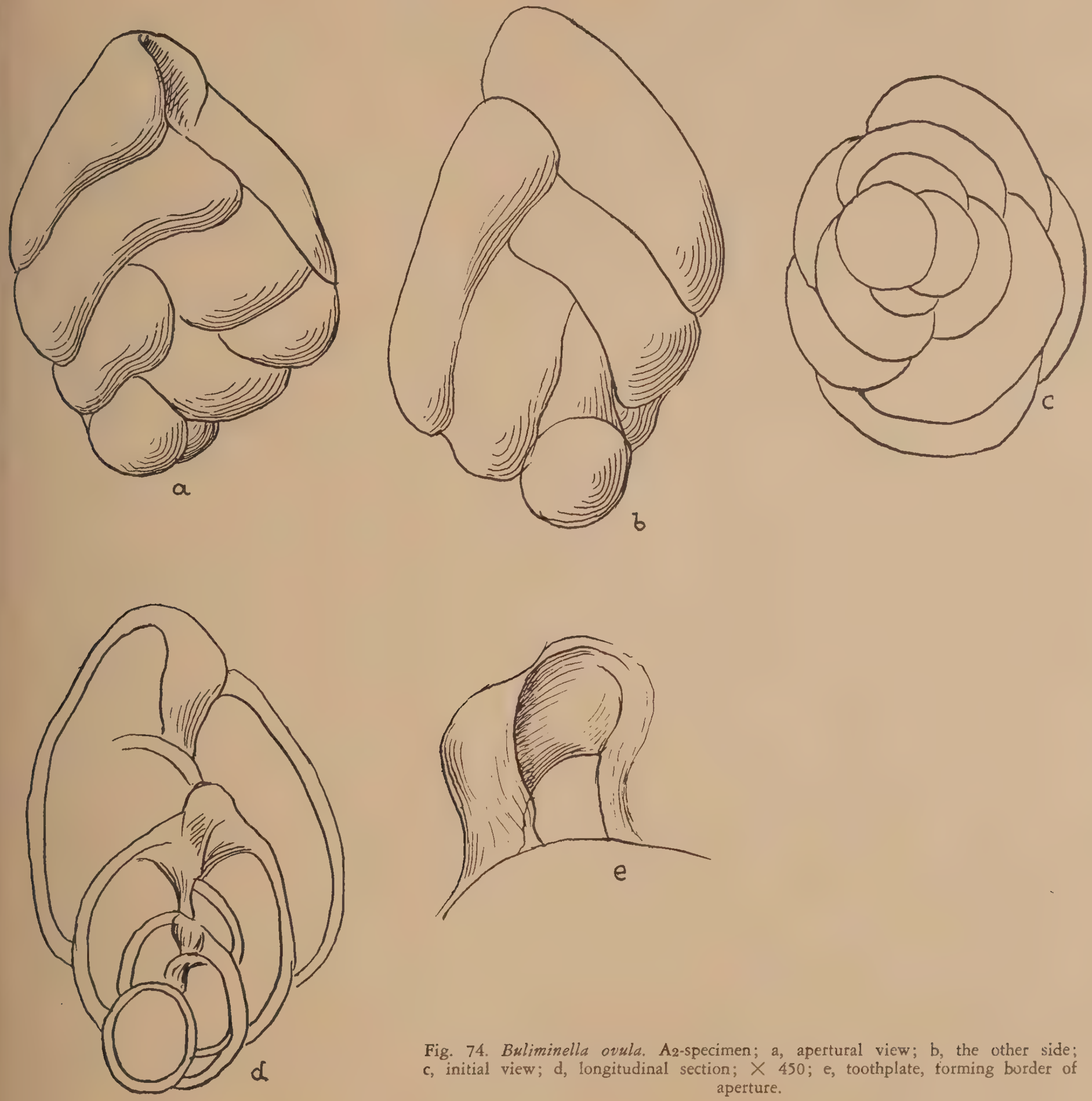


Fig. 74. *Buliminella ovula.* A2-specimen; a, apertural view; b, the other side; c, initial view; d, longitudinal section; × 450; e, toothplate, forming border of aperture.

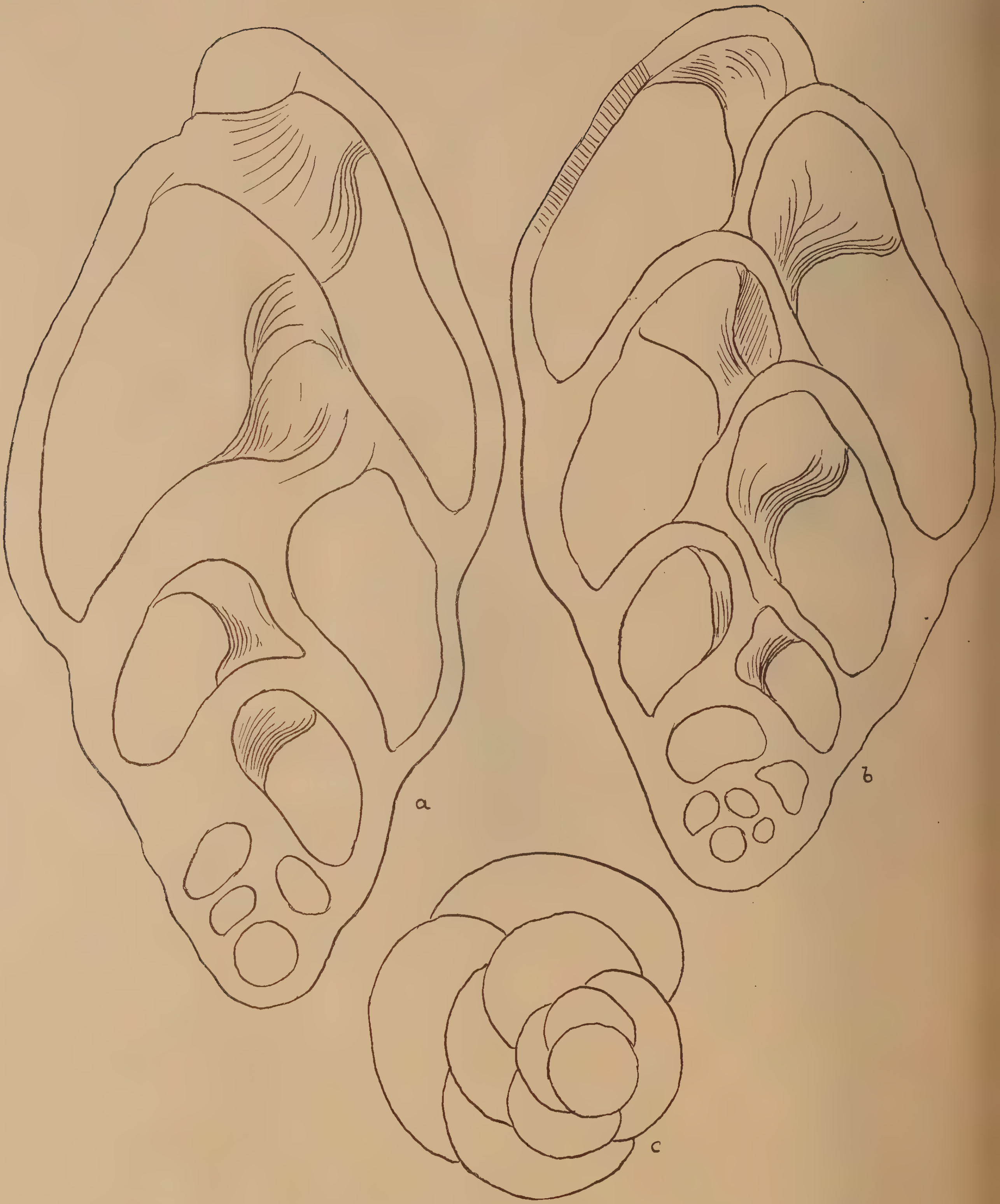


Fig. 75. *Bulimina spec.* from the Upper-Turonian. a and b, longitudinal sections; c, initial view; × 450.

s an opportunity to understand the real development of successive chambers in those forms, in hich the coiled arrangement of the chambers, which is ithout doubt the more primitive one, has developed into a iserial or even uniserial arrangement.

Buliminella madagascariensis (d'Orbigny)
var. *spicata* Cushman et Parker
(Figs. 77-79)

This species is always very rare; it was only met with n megalospheric specimens at 2° 26′ S., 99° 35′ E., depth 82 fathoms and in 1° 51′ S., 99° 36′ E., depth 683 fathoms. The species is distinguished from other *Buliminella* by its nitial spine.

The test consists of a single spiral of narrow, but long hambers which are slightly increasing, very slightly inflated, oiling round a massive axis. The spine is always found on he proloculus, and when seen from this spine, the test is ypically trochoid, and not triserially arranged as in *Bulimina.* Moreover the aperture and the toothplate are different from hose of any living or fossil *Bulimina.* The aperture is loop-haped, sutural, and is always found just at the axis of the pire. So we may call it ventral. It is slightly triangular in shape, and, when the last-formed chamber grows older, it is covered by a protruding lip formed by a poreless plate, covering the apertural face. When the chamber is quite young, this plate, also poreless, is hyaline; it forms the whole apertural face of the chamber. In thickened plates a peculiar structure is seen, just as is found in *Ehrenbergina hystrix,* radiating groves running from the aperture toward the margin of the plate. From the former aperture a complicated toothplate runs to the opposite border of the next aperture. It is irregularly twisted, is attached with its one side to the border of the aperture, which is directed toward the axis of the test (the proximal border), while its free part forms a flat, fan-shaped and very thin plate which runs toward the margin of the chamber, dividing the chamber in a small part situated between the aperture and the axis, and a larger one.

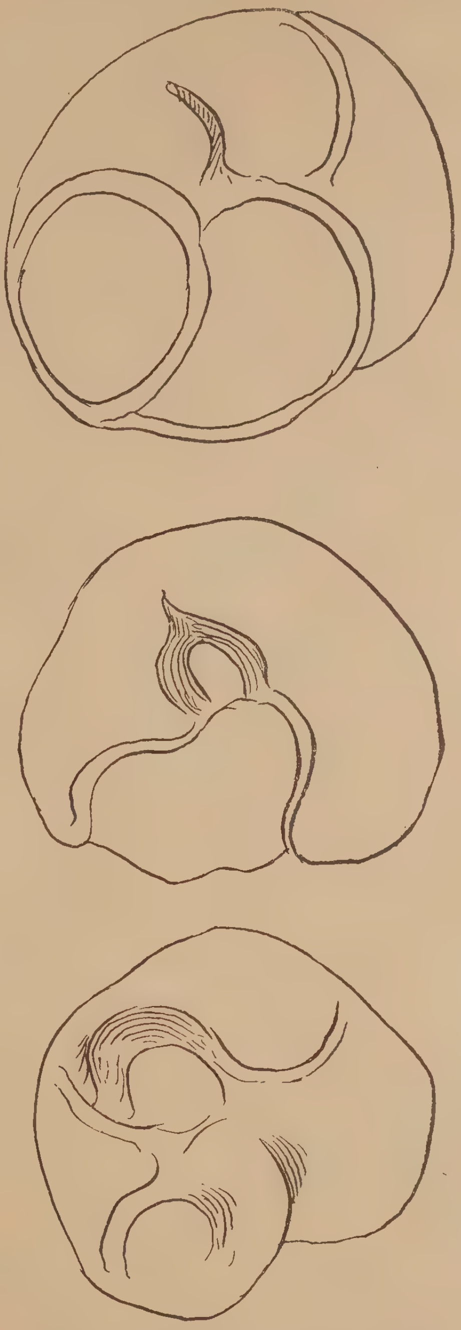


Fig. 76. *Buliminella spec.* from the Upper-Turonian. Successive transverse sections through a chamber beginning proximally; × 480; showing the toothplate.

The whole toothplate has the habitus of that of *Praebulimina* or *Cassidella,* but with some development in the direction of *Ceratobulimina.*

The test itself shows very fine, and very densely placed pores in its walls, thus once more pointing to *Praebulimina* or *Cassidella.* On the other hand the typical trochoid coiling of the test indicates a relation with forms like *Ceratobulimina* or *Lamarckina.* I have observed specimens from

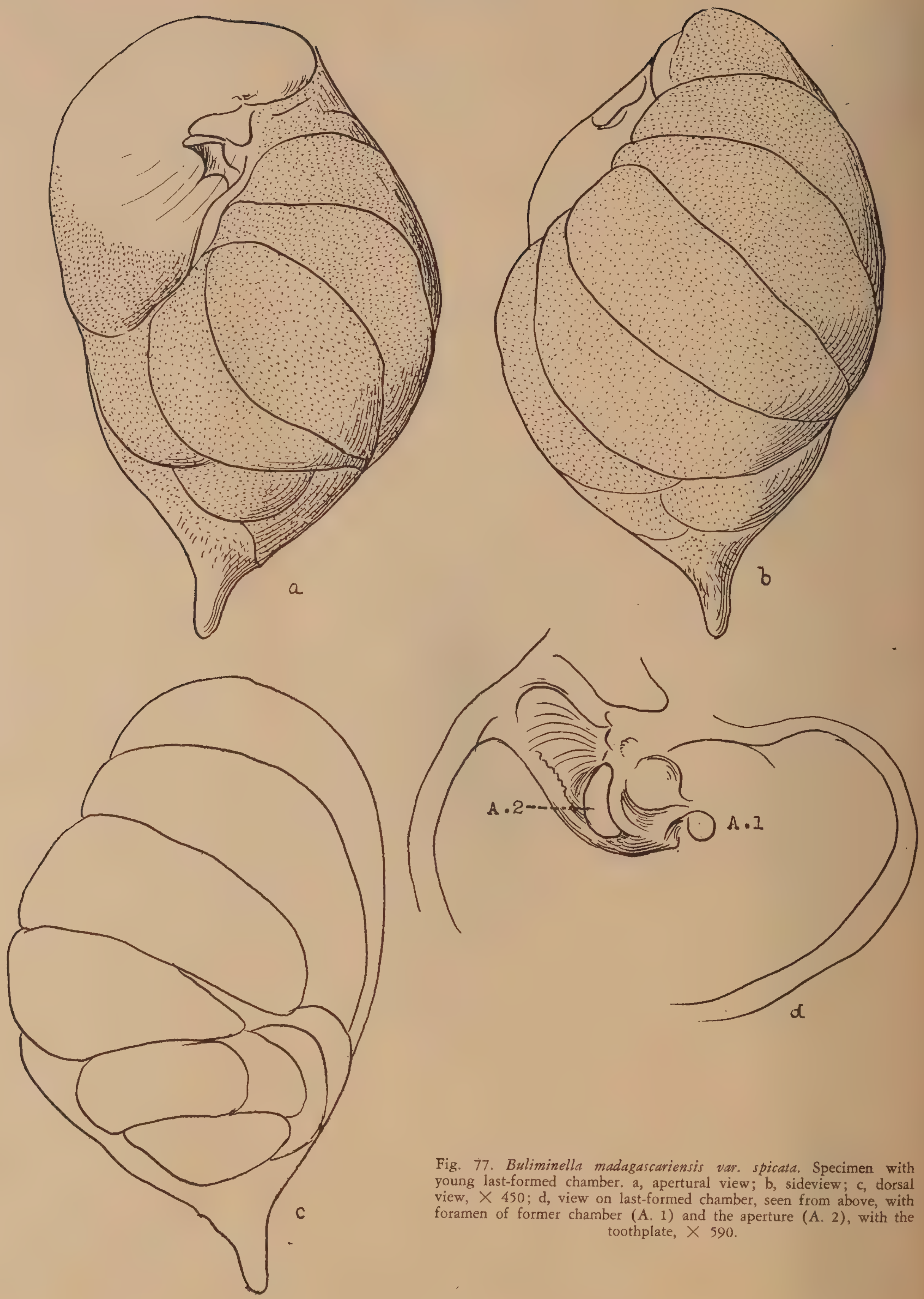


Fig. 77. *Buliminella madagascariensis var. spicata.* Specimen with young last-formed chamber. a, apertural view; b, sideview; c, dorsal view, × 450; d, view on last-formed chamber, seen from above, with foramen of former chamber (A. 1) and the aperture (A. 2), with the toothplate, × 590.

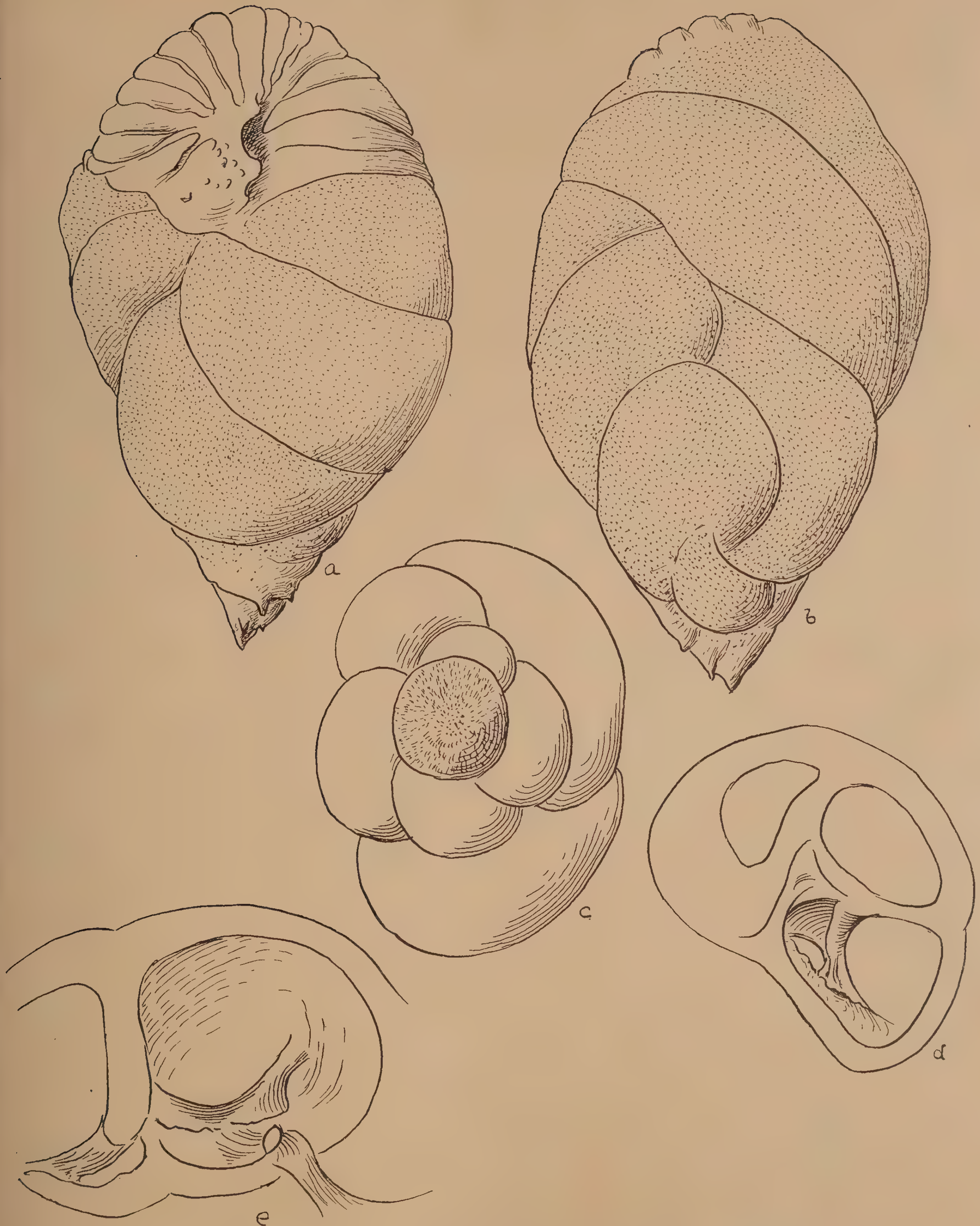


Fig. 78. *Buliminella madagascariensis var. spicata.* Specimen with adult last-formed chamber. a, apertural view; b, dorsal view; c, initial view; d, transverse section through last whorl, showing toothplate and aperture of last-formed chamber, seen from apertural face; × 450; e, chambers showing toothplates and base of toothplate at border of septal foramen; × 590.

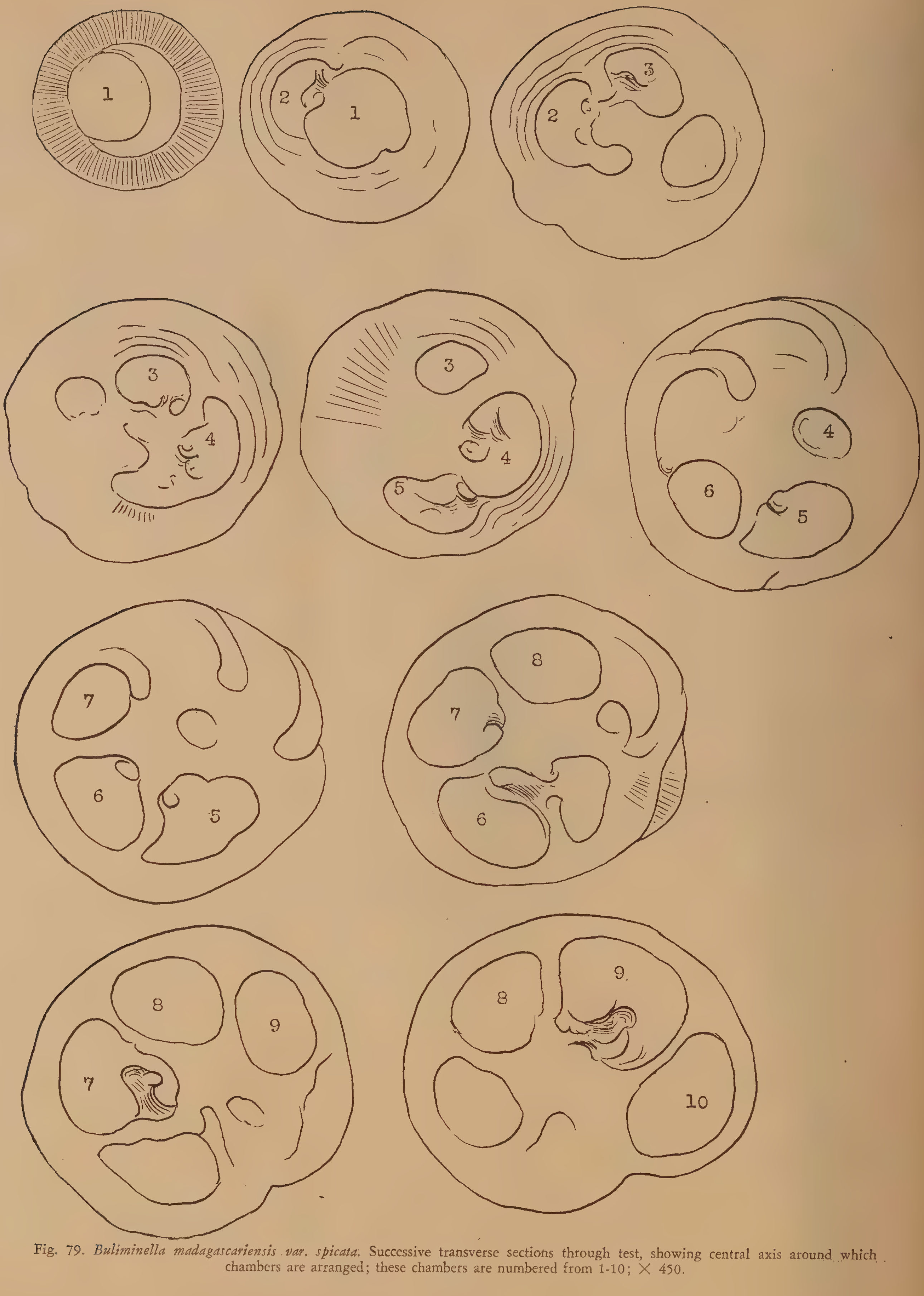

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Fig. 79. *Buliminella madagascariensis var. spicata.* Successive transverse sections through test, showing central axis around which chambers are arranged; these chambers are numbered from 1-10; × 450.

the Barthonien of the Netherlands, kindly sent to me by the Geological Survey which are quite similar to this species, found in the Pacific, and which show the same toothplate, also pointing to *Cassidella* and to *Ceratobulimina.* So the species is an ancient one, and it shows to be longliving also.

This species has been described by Sidebottom (Journ. Roy. Micr. Soc., 1918, p. 123) as *Bulimina elegantissima* var. *apiculata* Chapman.

Buliminella elegantissima (d'Orbigny)

(Fig. 80)

The species is not a common one in the Archipelago, as it was found in only a single typical specimen off Merak, depth about 10 fathoms. It occurred, however in several gatherings off Peru in abundance, so that I can give here some further details of the species. The species has been fully discussed by Höglund already, who, however, failed in giving details on the structure of the toothplate. He says (p. 218, 1947):

"The aperture is situated in the uppermost part of the apertural face, which is here somewhat sunk like a crater near the boundary of the preceding convolution. The constructional details of the aperture are particularly difficult to discover, owing to the minute size and almost complete transparency of the test, and I have not entirely succeeded in this, unfortunately. It seems, however, as though the aperture were constructed in principle as in *Bulimina marginata* and as though an "internal trough" were present."

I had no difficulties at all in detecting the inner structure of the apertural construction; Höglund does not mention the particular typical outer border of the toothplate with its sawed end, and thus it may be, that his species is different from that, found in the Pacific. I stated, that the specimens, found off Peru are quite the same species, as was found at Merak. Cushman and McCulloch have described and figured several "varieties" of the species from the same localities, but I believe, that these varieties are only generic forms of a single species; I found them together in my material, with all links between. It may be possible, that several species of "*Buliminella elegantissima*" exist; I was not able to trace this question, as I have no material available from the Norwegian coast.

The toothplate has nothing whatever to do with that of *Bulimina marginata,* at least not with the species, occurring under this name in the Pacific. The plate is of a much more simple type, as is found in all *Buliminellae.* It consists of a cornet, running from the border of the former loop-shaped aperture towards the border of the next one. Its attached part runs along the inner wall of the chamber, forming the lower border of the next aperture which is smooth and distinct; its free part runs along the upper border of the loop-shaped opening and, with its sawed free end forms a sawed somewhat protruding border of the aperture too.

The whole texture of the test seems to indicate some relation with *Buliminoides williamsoni.* The apertural face seems to have been formed by the toothplate only at its uppermost part, where often a typical ridge can be followed running from the attached part of the toothplate toward the end of the test. Here the wall of the apertural face always is lacking any pores whatever. But the lower part of the elongated apertural face is doubtless formed by a real wall and not by a toothplate, as it shows scattered fine pores. This lower part of the wall may be the inner wall of the

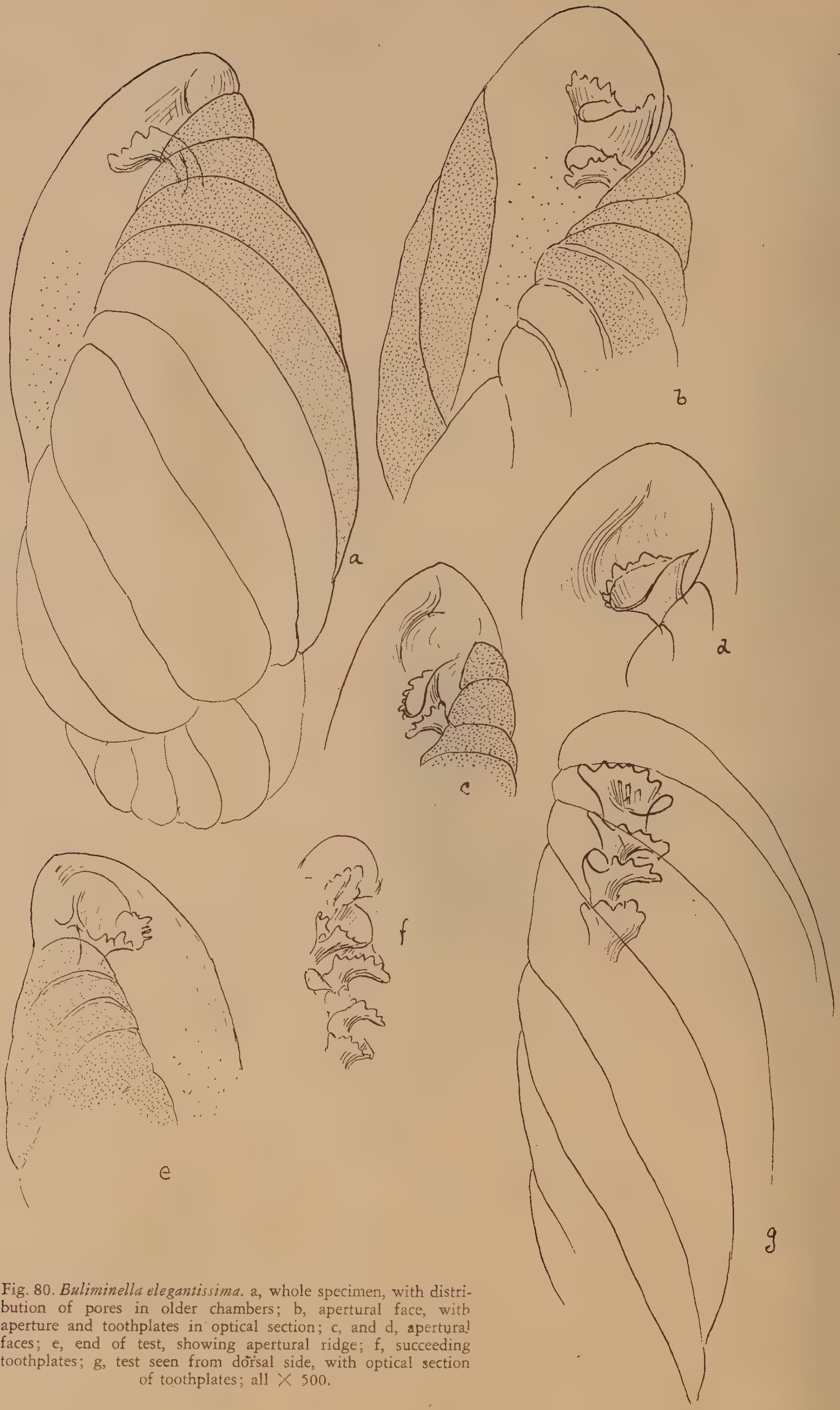


Fig. 80. *Buliminella elegantissima*. a, whole specimen, with distribution of pores in older chambers; b, apertural face, with aperture and toothplates in optical section; c, and d, apertural faces; e, end of test, showing apertural ridge; f, succeeding toothplates; g, test seen from dorsal side, with optical section of toothplates; all × 500.

species *Buliminoides williamsoni*; in this way that species has got a much denser spiral than *B. elegantissima.*

The species was found by d'Orbigny in the same localities, in which I found them. Thus we can be sure, that the species, here analysed, is that which d'Orbigny described as *Bulimina elegantissima.* It was found by Sidebottom off the East Coast of Australia (Journ. Roy. micr. Soc., 1918, p. 122-123).

The species had been recorded from the Miocene of Georgia by Cushman; as no details are given of the toothplate, one cannot be sure, that this is the same species, as described by d'Orbigny from the Coast of Peru (Contr. Cushman Lab., Vol. 21, pt. 1, 1945, p. 7, pl. 2, fig. 6).

Buliminoides williamsoni (Brady)
(Fig. 81-84)

This wonderful species occurred very rarely in gatherings from south of Sumatra and near Flores. It also ocurred at St. 49^a, 8° 23′ S., 119° 4′ E., depth 69 m, and at Anchorage Merak. All specimens found were megalospheric(?), the proloculus ranging from 12 to 50 μ.

A careful examination shows, that the first chambers are trochoidally arranged, and that normal rotalide foramina exist between them. They coil up very rapidly, leaving a narrow umbilicus free, which exists throughout the whole spiral up to the apertural face of it, where it opens into a central opening, which has been looked at hitherto as an aperture. As the chambers are curling down around this umbilicus obliquely, several of them end at the aperture around the opening of it. The base of the shell always is oblique to the axis. Transversely to the curling of the chambers run the typical costae, which make the real structure of the shell very unclear. Transverse and longitudinal sections revealed, that most of the inner walls of the chambers are absorbed, so that they open freely into the umbilical hollow. It may be, that these openings are nothing but ventral foramina, but this is not certain. Mostly five chambers are found in a transverse section.

The pores are not only visible on the outer surface, but also on the dorsal and ventral walls of the chambers, as is the case in many Rotaline shells.

The toothplate in this species seems to be somewhat reduced; but the highly ornamented apertural face is formed by it. In case that the proloculus with diameter of 12 μ is microspheric, the species seems to be holotrimorphic.

Buliminella subtenuis (Cushman)
(Fig. 85)

This species was found in several well-preserved specimens at the stations:

2° 36′ S., 99° 35′ E., 582 fathoms, bottom temp. 6°6 C;
2° 56′ S., 99° 58′ E., 405 fathoms, bottom temp. 8°0 C;
2° 26′ S., 100° 0′ E., 222 fathoms.

It has been described by Cushman as *Bolivina tenuis* Brady, and later as *Bolivina subtenuis* (Special Publ., No. 6, Cushman Lab. Foram. Res., 1936, p. 57, pl. 8, fig. 10).

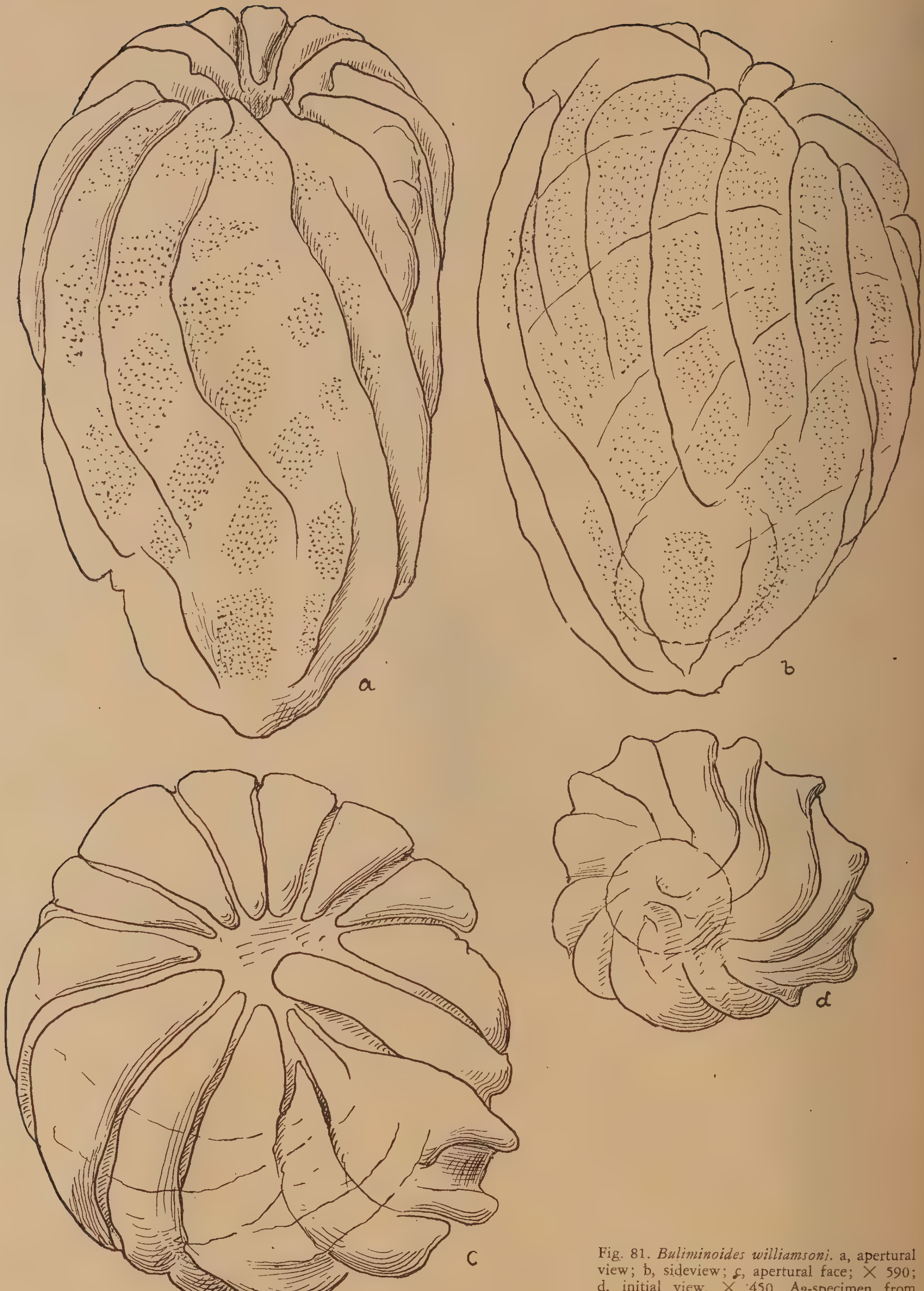


Fig. 81. *Buliminoides williamsoni*. a, apertural view; b, sideview; c, apertural face; × 590; d, initial view, × 450. A_2-specimen, from St. 49^a.

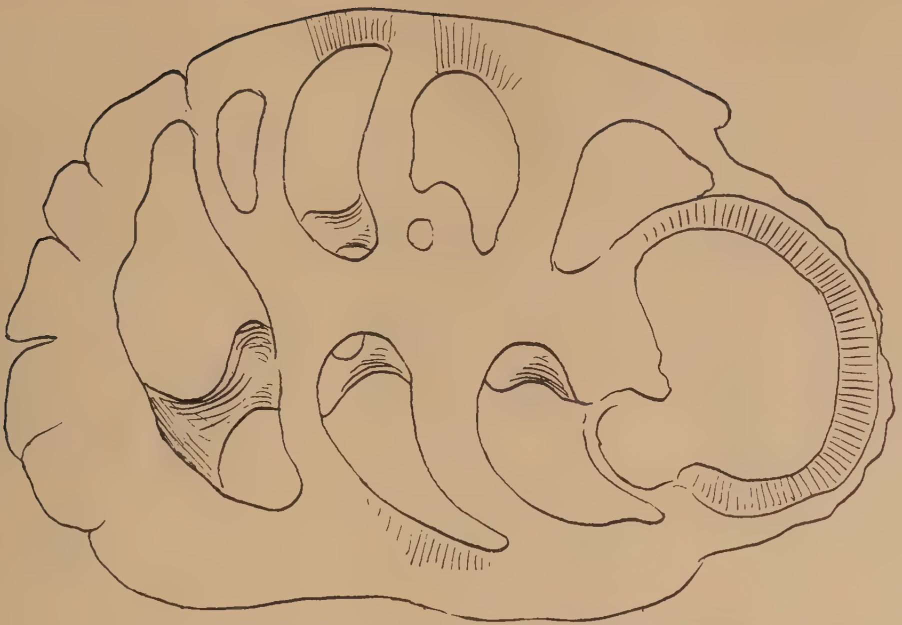


Fig. 82. *Buliminoides williamsoni.* Section through the individual of textf. 81, showing large proloculus, solid not absorbed axis and toothplates. × 630.

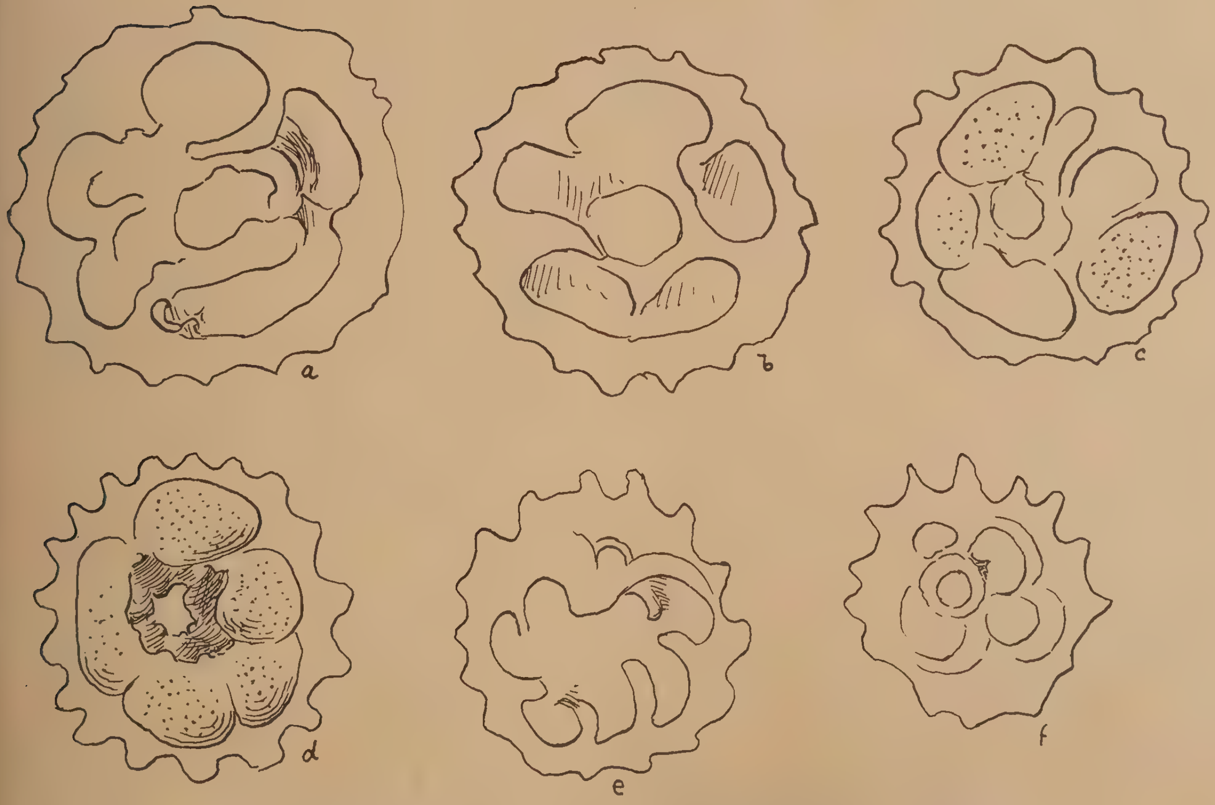


Fig. 83. *Buliminoides williamsoni.* Transverse sections through microspheric specimen; showing toothplates (a, e), pores on transverse walls (c, d), hollow umbilical axis (d, c) and the trochoid initial part (e, f). × 450.

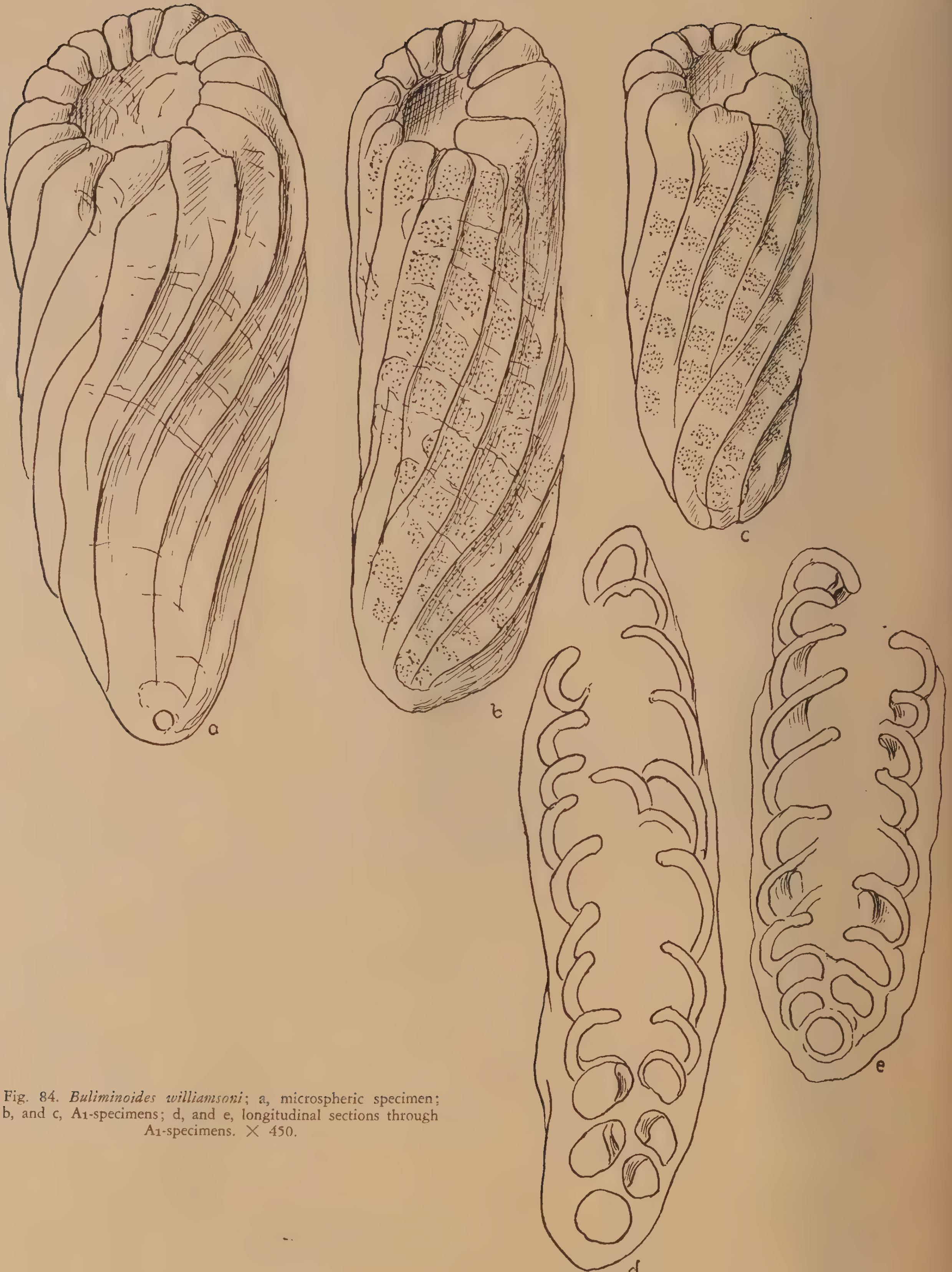


Fig. 84. *Buliminoides williamsoni*; a, microspheric specimen; b, and c, A1-specimens; d, and e, longitudinal sections through A1-specimens. × 450.

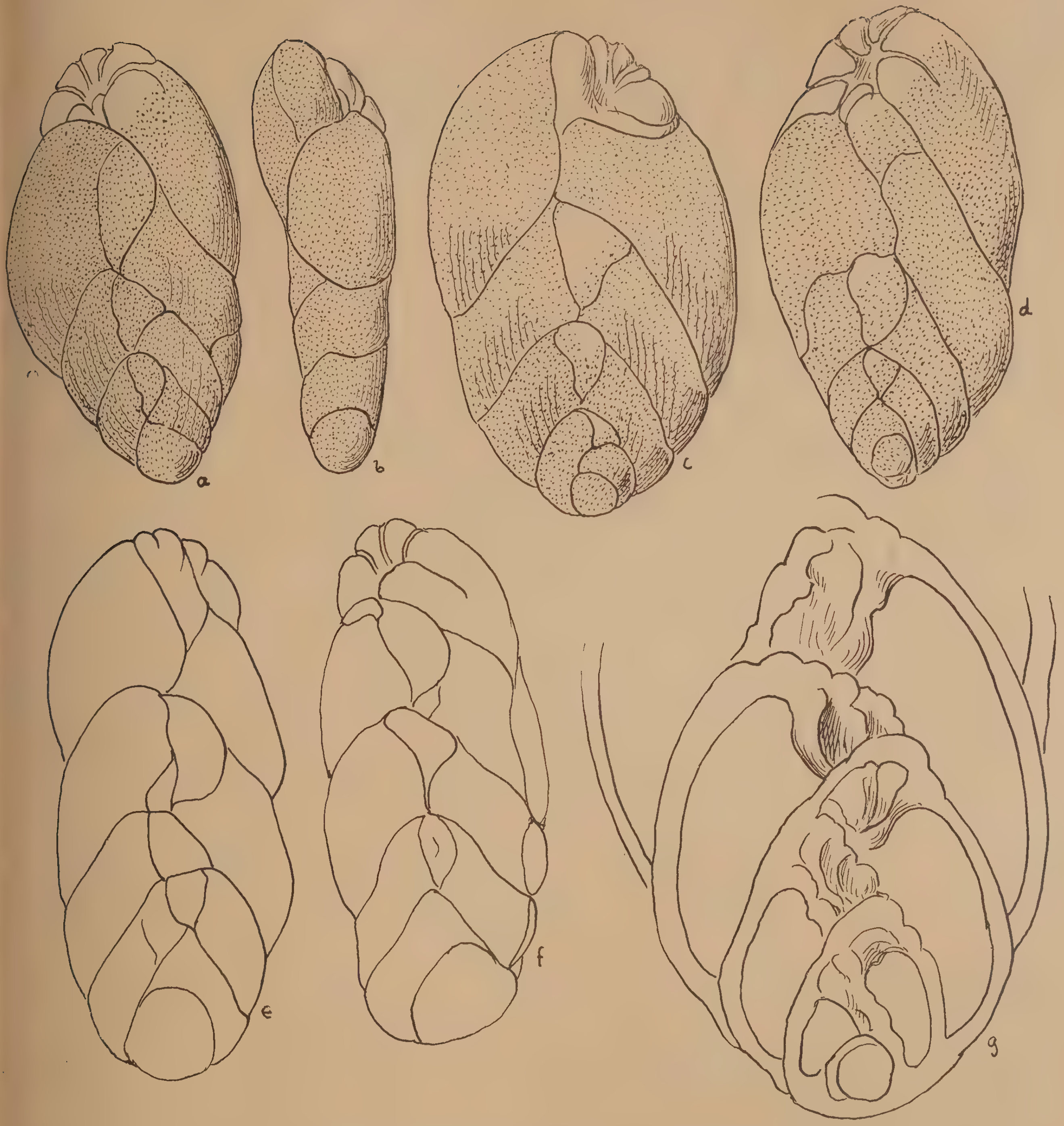


Fig. 85. *Buliminella subtenuis.* a-d, several specimens, b, from aside; e and f, two views of specimen with very large proloculus; g, longitudinal section, showing toothplates. a-f × 450, g × 590.

The description by Cushman (Spec. Publ., No. 9, 1937, p. 148) is very accurate, but for some points:

"Test much compressed, nearly as broad as long, greatest width just above the middle, periphery subacute, not keeled; chambers distinct, very broad and low, slightly inflated, increasing very rapidly in size as added, comparatively few, the inner portion often appearing as though separated from the main portion; sutures distinct, strongly curved, slightly depressed; wall smooth, finely perforate; aperture somewhat at one side, rounded, with a very slight lip and often with radiating lines above the aperture itself. Length 0,25-0,30 mm; breadth 0,20 mm; thickness 0,05 mm.

The types are from Samoa. This is a rare species, known only from the Fiji and Samoan Ids.

Bolivina subtenuis is a peculiar species in the excentric aperture and the tendency for the inner ends of the chambers to become subdivided."

The species was described under the same name in 1942 by Cushman (U. S. Nat. Mus., Bull. 161, pt. 3, 1942, p. 29).

Thus this species is not confined to the Fiji-region, as it is found in several gatherings south of Sumatra, in the Mentawei-basin.

It shows all characteristics of the genus *Buliminella,* none of that of the genus *Bolivina.* As in many typical species of *Buliminella,* the toothplate is thick and simple, and the aperture with radiating lines; as in *Buliminella,* the test consists of yellowish chalk, with very fine pores; the test in our species is compressed, whereas in most species of *Buliminella* it is rounded on transverse section; but, while in *Bolivina* the chambers are alternating in respect to their inner structure, as has been shown by Höglund, here they are arranged in a spiral, so while the aperture of one chamber is situated at one of the flat sides of the test, that of the next chamber is situated at the other side. On the surface of older chambers a fine ornamentation is seen of fine longitudinal lines of pustules. Otherwise the test is smooth, except for the radiate mouth. These radiate lines are formed by the attached part of the toothplate which is bending toward the aperture, leaving only a small rounded opening free. The "showing signs of a subdivision of the chambers" (1942), mentioned by Cushman, is nothing but the fact, that the toothplate, running from the foramen of the former chamber to the aperture of the next one, has a distinct suture at the outer side of the chamber with its attached part.

All specimens observed were of the A-generation. It is possible, that the B-form may show at its beginning a coiled initial end.

Genus **Allomorphina**

This genus, with its extremely fine pores, its triserial arrangement of the chambers, at least in the earlier whorls, its very peculiar toothplates, already discovered by Brotzen (1948), shows a very strong resemblance to *Buliminella,* and no resemblance whatever to *Chilostomella.* So I have removed it from that genus, and placed it among the *Buliminellidae.* There are at least three different species known, two of which (*A. trigona* Reuss and *A. halli* Jennings) are fossil, the third one having already been discovered by Brady, showing to be a species, closely allied to *A. halli,* now named *A. pacifica.* All three species have shown to possess similar toothplates, showing the contorted shape of the plates, found in *Buliminella.*

A study of *Chilostomella ovula* has shown, that that species does not show any trace of a toothplate, and thus *Allomorphina* cannot belong to the *Chilostomellidae.* Brotzen is inclined to place it among the *Ceratobuliminidae*; but the triserial arrangement of the chambers is not sustaining this view in my belief.

Allomorphina pacifica nov. spec.
(Fig. 86)

In the Challenger Report Brady mentioned *Allomorphina trigona* Reuss from recent material in the Indo-Pacific. The species seems to be very rare, as no later author did mention it. Cushman did not find it in his material, when describing the Foraminifera from the North-Pacific, and in his material from the Philippines he gave it from 6 stations, one of which was the Gulf of Boni in the Malayan Archipelago, always rare.

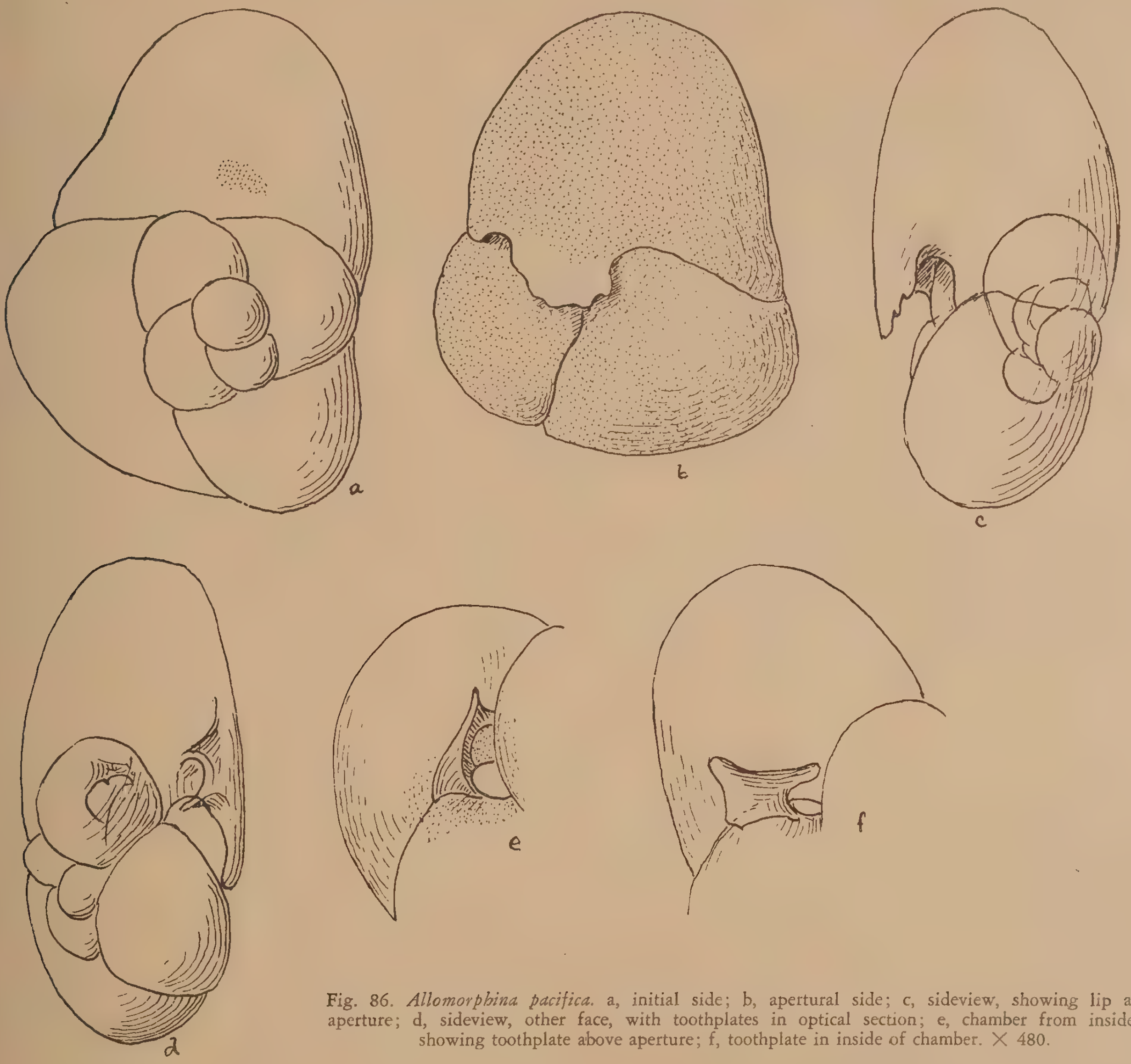


Fig. 86. *Allomorphina pacifica.* a, initial side; b, apertural side; c, sideview, showing lip at aperture; d, sideview, other face, with toothplates in optical section; e, chamber from inside, showing toothplate above aperture; f, toothplate in inside of chamber. × 480.

I found it in several specimens at 2° 26′ S., 99° 35′ E., 582 fathoms. It shows no resemblance to the species, described by Reuss from the Cretaceous of Maestricht, and so cannot be the same species. In the cretaceous species the walls are relatively thick, about 20 μ, whereas in the

Pacific species the walls are extremely thin. In the cretaceous species the aperture is a narrow slit, without a lip; in the Pacific species the aperture begins with an arched opening, and then is covered by a large umbilical lip. In both species however, the toothplate at the inner side of the aperture is nearly the same, in the cretaceous species not so well developed as in the Pacific one.

I studied a third species of *Allomorphina* from the Paleocene of the Netherlands, and it showed to be identical with the species of Brotzen's, *Allomorphina halli* Jennings (Sver. Geol. Unders., Ser. C., No. 493, p. 127-130, 1948). So I could very well describe the three species, now known exactly to form a single genus. The Pacific species showed to be very closely related to *Allomorphina halli,* but for the more pointed endchamber, in which it resembles *A. trigona* Reuss.

Description:

Chambers arranged in a triserial spiral, rapidly increasing in size, and with a blunt somewhat pointed end of the later chambers. In dorsal or ventral view the test is somewhat triangular, and the first chambers are not so close-coiled as is the case in cretaceous *A. trigona.* Walls very thin and translucent, with very fine pores. At the ventral side the aperture forms an arched opening at one side of the suture, whereas in the middle of the suture a very well developed lip with somewhat dentated border is formed, covering the rest of the aperture. At the inner side of the lip a toothplate is adhering, running somewhat folded toward the upper border of the former aperture, now the septal foramen. These septal foramina are also arched, obviously developed from the arched part of the aperture. The whole habitus of toothplate and aperture suggests that the aperture is a protoforamen, and thus the species belongs to the Protoforaminata. The very fine pores, together with the shape of the toothplate and the triserially arranged chambers point to the *Buliminellidae.* So I am convinced, that the genus *Allomorphina* is a pelagic *Buliminella.* This view has been stated by the study of the cretaceous species *A. trigona,* which in its full development even shows a tendency to become biserially arranged, as is found too in *Buliminella.*

This study shows moreover, that the genus *Chilostomella,* in which no traces whatever have been found of a toothplate, cannot be related to *Allomorphina.*

Family *Buliminidae*

(Fig. 87)

This family contains the genera *Praebulimina, Bulimina, Globobulimina, Reussella* and the sub-genus *Chrysalidinella.* So it is more narrowly concepted, than Cushman does. Genera as *Buliminella, Robertina* and *Robertinoides* belong to quite different groups, as they show the very fine pores and opaque shells of *Cassidulinoides,* while their toothplates are of quite a different shape than those of *Bulimina,* though modern *Buliminae* show some peculiarities in the toothplate, which are also found in those of *Robertinoides.* The genera *Virgulina* and its allies have been separated into a special family, and those like *Bolivina* into another one. *Buliminoides* was found to belong to the *Buliminellidae,* the real state of *Chrysalogonium* is not yet sufficiently cleared up.

Though *Bulimina* is mentioned from Jurassic strata, its occurring there is not at all certain, as the inner structure of those species has not yet been carried through. I myself studied some specimens of a *Bulimina*-species from the Upper Cretaceous of the Netherlands, kindly given to me by the Geological Survey of the Netherlands. It shows externally the characteristics of *Bulimina,* but for the tooth, which is totally different. The walls are thick, as in *Bulimina,* the chambers more or less inflated, as described in several species from the Upper Cretaceous of Sweden by Brotzen, but the shape of the toothplate is rather simple, and shows all characteristics of that of *Cassidella.* So it is obvious, that we deal here with a species, which on one hand shows some characters of *Bulimina,* on the other hand has typical characteristics of *Cassidella.* The toothplate here consists of a simple folded building, running along the basal wall of the chamber unto the border of the next aperture, forming here its protruding border, but nothing more. No tooth, no free part of the plate, no sawings along the end of the attached part. When considering the toothplate as the most typical characteristic to rely on, one has to consider these forms from the Cretaceous as ancestors of real *Bulimina,* which show many very typical characteristics of *Cassidella,* or, may be, of *Virgulina.* So I happened to be convinced, that these forms must be named with a different generic name, and I will call them *Praebulimina.*

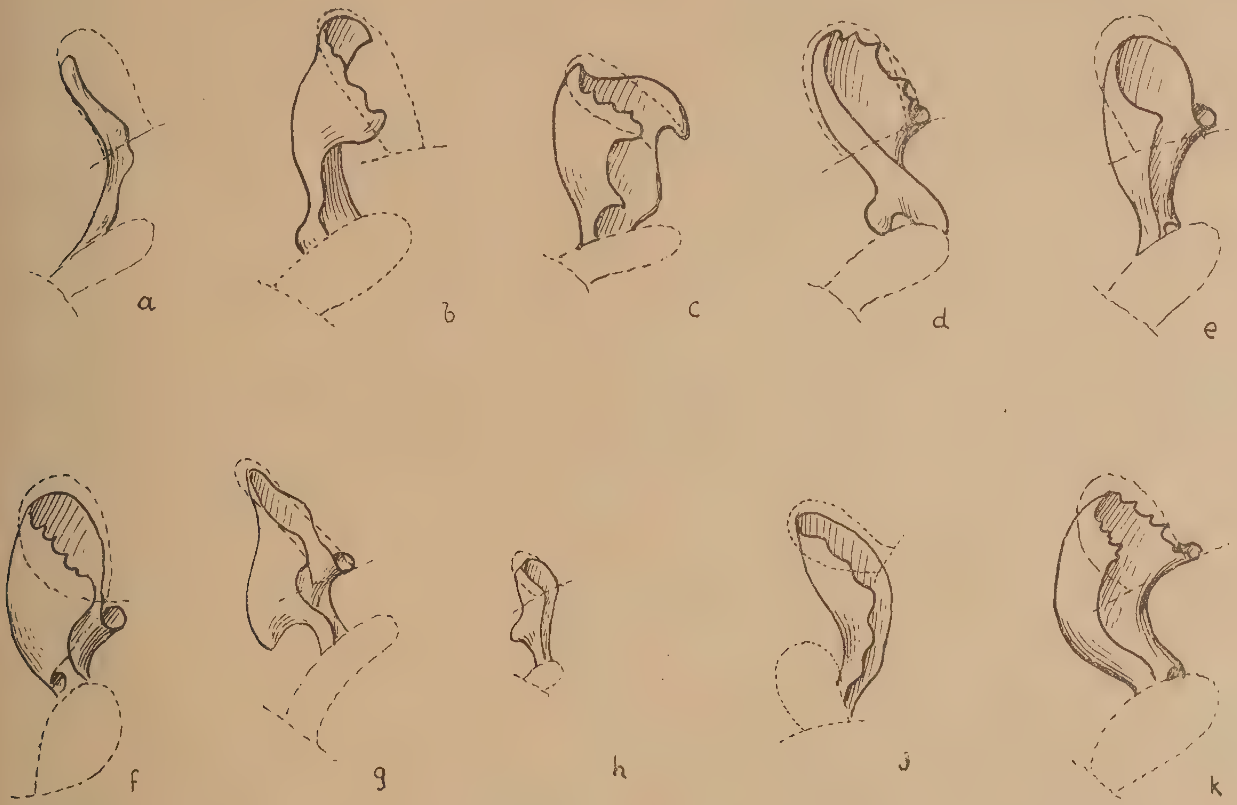


Fig. 87. Toothplates of the *Buliminidae.* a, *Praebulimina* spec. (Upper Cretaceous); b, *Bulimina trigonalis* (Paleocene); c, *Bulimina rostrata*; d, *Bulimina inflata*; e, *Bulimina buchiana*; f, *Bulimina marginata*; g, *Reussella spinulosa*; h, *Chrysalidinella*; j, *Bulimina debilis* (Paleocene); k, *Bulimina aculeata.*

From this *Praebulimina* from the Upper Cretaceous the other genera of the family have developed. The genus *Bulimina* forms two distinct groups, the one conservating the fine pores of the ancestors, such as *Bulimina debilis* and *B. aculeata,* the other having coarser pores, which are more widely separated from each other, developing in the Tertiary *(Bul. trigonalis)* and giving rise to most recent species of *Bulimina.*

These *Buliminae* with coarser pores may already have developed in the Cretaceous, and from those *Buliminae Reussella* is an offspring; several species are already known from the Upper Cretaceous, and a typical recent form, *Reussella weberi,* shows very coarse pores only at the basal sutures of the chambers; a typical late characteristic *Chrysalidina* has preserved pores on its whole wall, but shows uniserially arranged chambers, lacking the toothplate in the adult stages.

From some tertiary form with coarser pores *Globobulimina* was an offspring. It developed already in the Tertiary, as a Miocene form, showed to me in the Geological Survey, proves; this miocene form had a much more simple toothplate than those, found in recent species, as shown by Höglund. The genus is nothing but a *Virgulina,* which became pelagic, with thin, inflated walls. The pores are those of the groups with larger pores, so the genus must be an offspring of that group. The pelagic life has altered the destination of the toothplate. At first the plate which in bentonic forms seems to have the function of place for attachment of musculous protoplasm, reduced, as this function was no longer necessary; but then, as a spreading-net was formed for floating purpose, the free extending border of the plate was gradually shaped into a fan, as is shown in recent species, in which several modifications of the plate are found. This is moreover a typical instance of the rule of Dollo, as the folded free part, which in bentonic forms is forming the functioning part of the toothplate, is reduced, and another part, the border-end of the plate, becomes a new organ.

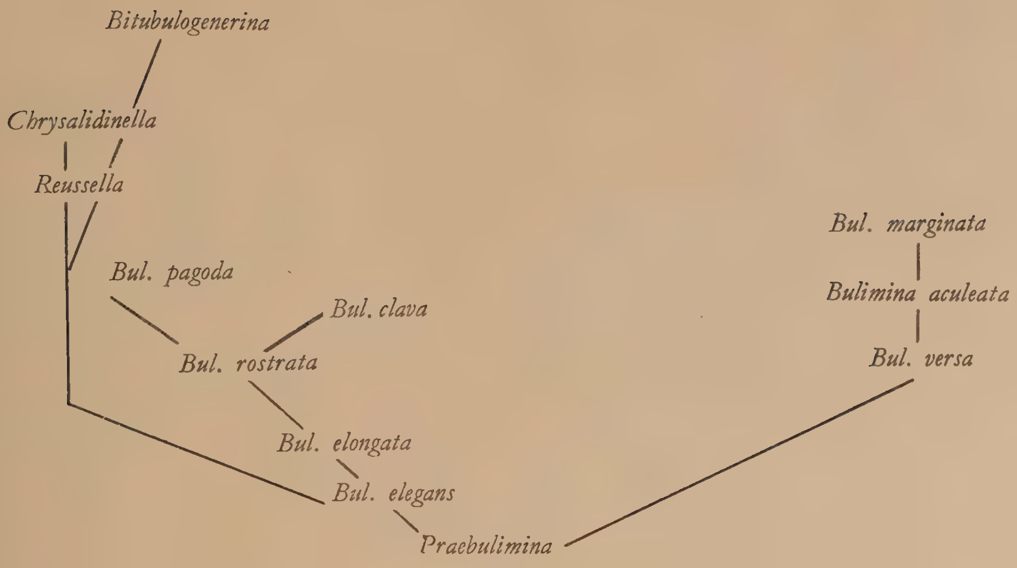
The toothplate of the *Buliminidae* is in so far different from that in the family of the *Bolivinidae,* as in the latter family the free tooth becomes highly developed and forms the tooth in the aperture. In *Bulimina* and its allies the free part of the toothplate is more or less attached to the border, opposite to that, at which the plate is attached already, and often runs down unto the very base of the aperture, forming with a folded part, which in recent forms becomes even a sipho, the secundary foramen, found aside the base of the primary aperture. Such folding of the original free border of the toothplate, forming a second foramen, is found too in the genus *Robertinoides,* as Höglund showed.

It may be, that the new genus *Praeglobobulimina* shows a link between the ancestor with coarse pores (*Bulimina*) and real *Globobulimina.* This genus shows the inflated chambers, the ovoid megalospheric proloculus, the overlapping last-formed chamber, giving rise to the closed aperture in the sense, given by Höglund, but a toothplate which shows the free folded part well-developed, though already reduced in its lower part. Similar-formed toothplates do occur in other genera as well; it was found in *Bolivina* spec. of Höglund, and traces of this reduction are also found in *Bulimina rostrata* which, moreover, shows coarse pores.

This genus *Praeglobobulimina* shows, when it is true that this is a primitive *Globobulimina,* that the closed aperture is the primitive one and that the pillar-like toothplate of real *Globobulimina* is nothing but the attached part of a normal *buliminine* toothplate.

In *Globobulimina turgida* from the Norwegian coast Höglund described apical spines; they are situated at the basal sutures of the chambers, just as it is the case in *Praeglobulimina spinescens*; it is very interesting that this spinous *Globobulimina* shows a closed aperture. But its toothplate is that of *Globobulimina* already, and not that of *Praeglobobulimina.*

The scheme, given here, shows the relationships between the different genera and species of the family of the *Buliminidae.* As in the *Bolivinidae,* the area, in which the highest development took place, is that of the Upper Cretaceous. It may be, that further investigation of the inner structure of fossil species of this family will show, that other links have to be placed between those, given here. Investigations in that direction are wanted therefore. The leading point in establishing this scheme was the shape of the toothplates. As I shall discuss later, I place the *Globobuliminae* in the vicinity of *Virgulina* and not of *Bulimina.*


Bitubulogenerina
Chrysalidinella
Reussella
Bul. pagoda
Bul. clava
Bul. rostrata
Bul. elongata
Bul. elegans
Praebulimina
Bul. marginata
Bulimina aculeata
Bul. versa

Literature: Cushman, J. A., Introduction to the study of the *Foraminifera;* Cushm. Lab. For. Res., Spec. Publ. No. 1, 1928, p. 242-259. Cushman, 1947, Geol. Survey, prof. paper 210-D, *Bulimina* and related *foraminiferal genera.* Höglund. H., *Foraminifera* in the Gullmar Fjord and the Skagerak; Zool. Bidrag fr. Uppsala, Vol. 26, 1947, p. 227-254.

Geographical distribution of the genera *Bulimina Reussella* and *Chrysalidinella*

When we consider forms with small pores, found closely together in the walls, as more primitive than those with wider pores, *B. aculeata* is the more primitive species, and consequently is found only in the eastern part of the Archipelago. Typically modern species, as *Chrysalidinella dimorpha* and *Bulimina "buchiana"* are only found in the western region. It is a remarkable fact, that a more primitive species, though not found as a fossil yet, *B. rostrata,* is found in both regions, together with *Reussella weberi, Bul. marginata* and *B. inflata. Reussella* was met with over the whole Archipelago.

Cushman (Bull. 100 U.S. Nat. Mus., 1921) records
Bul. marginata from 3° 34′ S., 120° 50′ E., southern Celebes;
Bul. inflata from 7° N to 3° S., and from 120° E.-121°E., around Celebes;
Bul. buchiana from 2° 51′ S., 118° 47′ E., Strait of Macassar;
Bul. aculeata from 7° N.-3° S. and 120°-127° E., east of Celebes;
Reuss. spinulosa from Sibuko-Bay, Borneo and Gulf of Tomini; Celebes;
Chrys. dimorpha from Celebes-Sea.

Genus **Praebulimina**

(Fig. 88)

It turned out necessary to erect a new genus for those *Buliminidae* found in the Upper Cretaceous of Sweden (Brotzen) and the Netherlands. Some of them are named by Brotzen *Buliminella* (Brotzen, F., Foraminiferen aus dem Schwedischen untersten Senon von Eriksdal in Schonen; S.G.U., Ser. C., No. 396, 1936), some *Bulimina* (Brotzen, F., Flinträinnans och trindelrännans geologi; S.G.U. Ser. C., No. 435, 190). I studied a species, which was kindly sent to me by the Geological Survey of the Netherlands, and it was found, that the aperture is a loop-shaped opening, at one of the borders of which is attached a very simple toothplate, which shows all characteristics of *Cassidella,* but not of recent *Bulimina.* I first was inclined to believe it a species of *Cassidella,* but for the fact, that the species was triserially built throughout, and the walls were thick. The pores showed to be very fine. Hence we have here a group of Foraminifera which shows characteristics of *Cassidella* together with those of *Bulimina,* and is obviously a link between those two groups. These Foraminifera should be distinguished from real *Bulimina* as well as from real *Cassidella,* and so I named them *Praebulimina.* I must point out, that only the study of the inner structure will reveal, whether a species from the Cretaceous should be called *Cassidella, Praebulimina* or *Bulimina.* I myself do not believe *Bulimina* to exist in the Cretaceous. So Brotzen's species from Sweden should be restudied in respect to their inner structure, especially in respect to their toothplates. The species here studied from the Cretaceous of the Netherlands, may be identical with *B. intermedia* Reuss, as its size is the same; but in Cushman's description (Geol. Surv. prof. paper 210-D, 1947, p. 80) one reads: "wall coarsely perforate", whereas in the specimens, found here, the perforation is extremely fine; this is the case too with all species of *Bulimina,* which I studied from the Cretaceous, so that this part of the description may be erroneous. I saw some specimens from Luschitz, Bohemia, the type-locality of *B. intermedia,* and here too the perforation was very fine.

Brotzen kindly sent to me a very good collection of his species, found in the Upper Turonian of Sweden. I could study his *Bulimina ovata* from Bornholm, and stated, that it must be very closely allied to the Dutch specimens, if not identical. Here too the walls are opaque and very finely porous, and the toothplate shows the characteristics of those, found in the *Cassidulinidae,* and not the higher structure of real *Bulimina.* So we have to give this whole group of cretaceous buliminine species a new generic name. They show the characteristics of *Cassidella* together with those of *Bulimina.* But in real *Bulimina* the toothplate is of a higher structural development than in the cretaceous species, and real *Bulimina* does not show opaque, but hyaline walls. The opaque walls could be very clearly shown in the material, Brotzen sent to me; the specimens are filled up with clear cristalline chalk material; in this colourless material the walls are distinctly seen in their yellowish colour, which indicates their opaqueness.

In Tertiary strata are occurring typical offsprings of this primitive group, for instance *Bulimina debilis.* They show the somewhat higher development of the chambers, more inflated, but the toothplate is of the more primitive shape. It is dubious, whether those forms must be called *Bulimina* or *Praebulimina.* Those *Buliminae* with fine pores, such as *Bulimina aculeata,* are descending directly from those primitive forms, in developing their toothplate; they occur already in the Tertiary, as

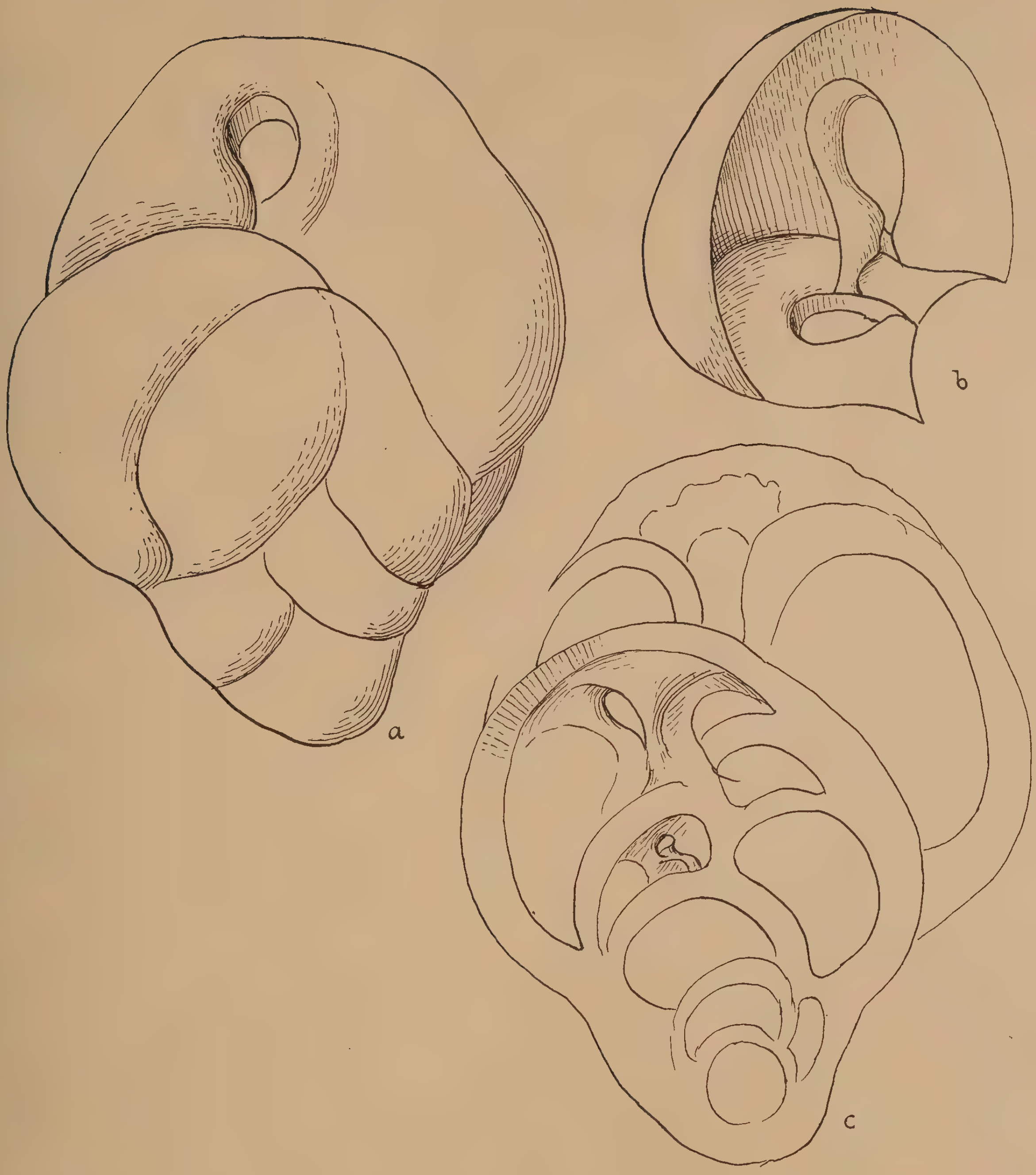


Fig. 88. *Praebulimina* spec., from the Upper-Cretaceous of the Netherlands; a, individual, showing open aperture; b, reconstruction of toothplate within an opened chamber; c, section through the individual a; × 440.

was found by Van Voorthuysen. But together with those forms with fine pores, in the Tertiary appear those forms with coarser pores and quite hyaline tests, as is shown by the paleocene *Bulimina trigonalis,* with a more recently shaped toothplate. From those forms developed the recent forms with coarser pores and hyaline tests, such as *Bulimina pagoda.*

Genus **Bulimina**

This genus seems to have been developed in the Lower Tertiary, apparently from a type, much resembling an inflated *Cassidella. Praebulimina* shows the outer conditions of a *Bulimina* with very fine pores, but has the primitive toothplate of a *Cassidella.* From such toothplates developed the more or less complicated toothplates of more modern typical *Buliminae.* In any case from those forms with fine pores, which pores are situated very closely together, developed the forms with coarser pores, which pores are more removed from each other. A miocene form, which I identificated with *Bulimina debilis* Martin from the Miocene of America, shows the fine pores too, but its toothplate is somewhat more developed, as it shows a free, lobulated tooth. The modern form with fine pores is *Bulimina aculeata,* and here the toothplate shows a modern complication, as the free part is folded to form a narrow sipho, ending just beneath the aperture, and forming a secundary aperture, while the free tooth now is sawed. Quite the same development show those forms with coarser pores, somewhat more removed from each other, leaving hyaline wallparts between. A paleocene form of them, totally lacking ornamentation on the outer walls, is found in *Bulimina trigonalis* Ten Dam, from which I could study large quantities, through the kindness of the Geological Foundation. This form shows a simple toothplate, in which the attached part is sawed in its protruding part, while the free part is narrow at its end. No sipho could be found, no secundary aperture either. A living form which may have derived from a species, closely allied to *B. elongata* is *Bol. rostrata,* which shows the attached part likewise sawed at its end, but the free part much broader, reaching the base of the aperture, and forming here by a typical tongue the beginning of a secundary foramen. Yet this is not a true foramen, as the folded sipho, developed by the folding of the border of the free part, is not found yet. From this form, which shows a peculiar ancient ornamentation of the test, only consisting of longitudinal costae, the modern forms *B. pagoda, B. inflata* and *B. marginata* may have been developed [1]). *B. pagoda* shows a simple folded sipho of the toothplate, and a well-developed secundary foramen, but a nearly smooth tooth-border, *B. marginata* has the attached border sawed, whereas *B. clava* shows sharp sawings at the free part, which ends in all these forms in a well-developed secundary foramen. In *B. clava* the base of the sipho is marked by a typical hook, as is found in a preliminary state in *B. rostrata.*

Thus the *Buliminae* show two different ways of development, one preserving the fine pores of the ancestors, the other becoming more coarsely perforated. In both groups the process ends with the forming of a secundary foramen by a folding-up of the free border of the toothplate. This phenomenon is not restricted to the *Buliminae,* as it once more is fully developed in the genus *Robertinoides.*

From the group with coarser pores two other lines have developed, the one of pelagic forms, forming the genus *Globobulimina,* and the other with yet coarser pores and a triangular test, *Reussella* and its subgenus *Chrysalidinella.*

Bulimina versa Cushman et Parker
(Fig. 89)

This species has been described and figured by Ten Dam (Die stratigraphische Gliederung des Niederländischen Paläozäns und Eozäns nach Foraminiferen; Meded. Geol. Stichting, Ser.

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[1]) The latter species shows, however, finer pores than most of its allied species.

C., V., No. 3, 1944, p. 111, pl. 3, fig. 12) as *B. cf. aculeata* D'Orbigny. But a study of the toothplate of this very simple *Bulimina* showed, that it has nothing to do with recent *B. aculeata,* as the toothplate is much simpler. The fine pores are quite similar to those of *B. aculeata,* and the thickness of the wall also. But the toothplate is a somewhat curved, but erect building, folded into a somewhat denticulated free tooth, and shows nothing of the high development of the toothplates of recent *Bulimina.* Thus it cannot be identical with a recent *Bulimina.* I identified it with some doubt with *B. debilis* Martin, from the Eocene of California. These unornamented *Buliminae* seem to be the most primitive ones too, in regard to the development of the toothplate which shows the characters of those of *Virgulina,* their ancestors.

Though the species does not occur in recent gatherings, I mention it here as it shows the ancestral form of recent species with fine pores. It may be identical with *Bulimina versa* Cushman et Parker. But Cushman describes the latter species as "coarsely perforate", whereas my specimens are finely perforate.

Bulimina trigonalis Ten Dam
(Figs. 90, 91)

This paleocene species has been described by Ten Dam (Ten Dam, A., Die stratigrafische Gliederung etc., 1944, p. 112, pl. 3, figs. 16-17) as *B. trigonalis,* as the chambers show a somewhat trigonal arrangement. But in the microspheric form the chambers never are twisted, and are situated in straight lines throughout the whole shell. Thus this character cannot be used, and the species seems to be allied to *B. elongata* D'Orbigny. I have to thank the Geological Foundation of the Netherlands for supplying me with beautiful material.

Statistic statement proved that (fig. 90):

In a gathering of 69 specimens 3 specimens showed to be microspheric. They had a proloculus of 6 μ diameter. The number of triserial rows of chambers in those specimens was 8 to 10. The length of the larger one was 0,27 mm. The shell was slender, with straight lines of chambers.

I am inclined to believe, that the A_1-generation shows a diameter of proloculus from 8 to about 12 μ, and these specimens show only 6-8 rows of triserial chambers. Most of them show not a tordated structure of the shell.

A second top is found at about 24 μ; this is the top of the A_2-form ranging in diameter of proloculus from about 13 μ up to 33 μ. Most specimens belonged to that generation, and here shells often show a spiral arrangement of chambers. In this generation the triserial rows mostly are 5 or 6, in some very large specimens they show 7 or even 8 rows, but this is very rare.

The walls of this species show much larger pores, and much wider spaces between them, than in the typical *aculeata*-group. Only, in the primordial part of the test the fine pores are visible of the primitive group and in microspheric specimens these fine pores are even found in the axial parts of later chambers. The species may be more or less identical with *B. microcostata* Cushman et Parker and *B. simplex* Terquem from the Eocene of France. But only the study of the toothplates of both species can solve this question which is very interesting. In recent species, such as *B. pagoda,* only the larger pores occur, even in the first chambers. Thus small pores form a primitive feature.

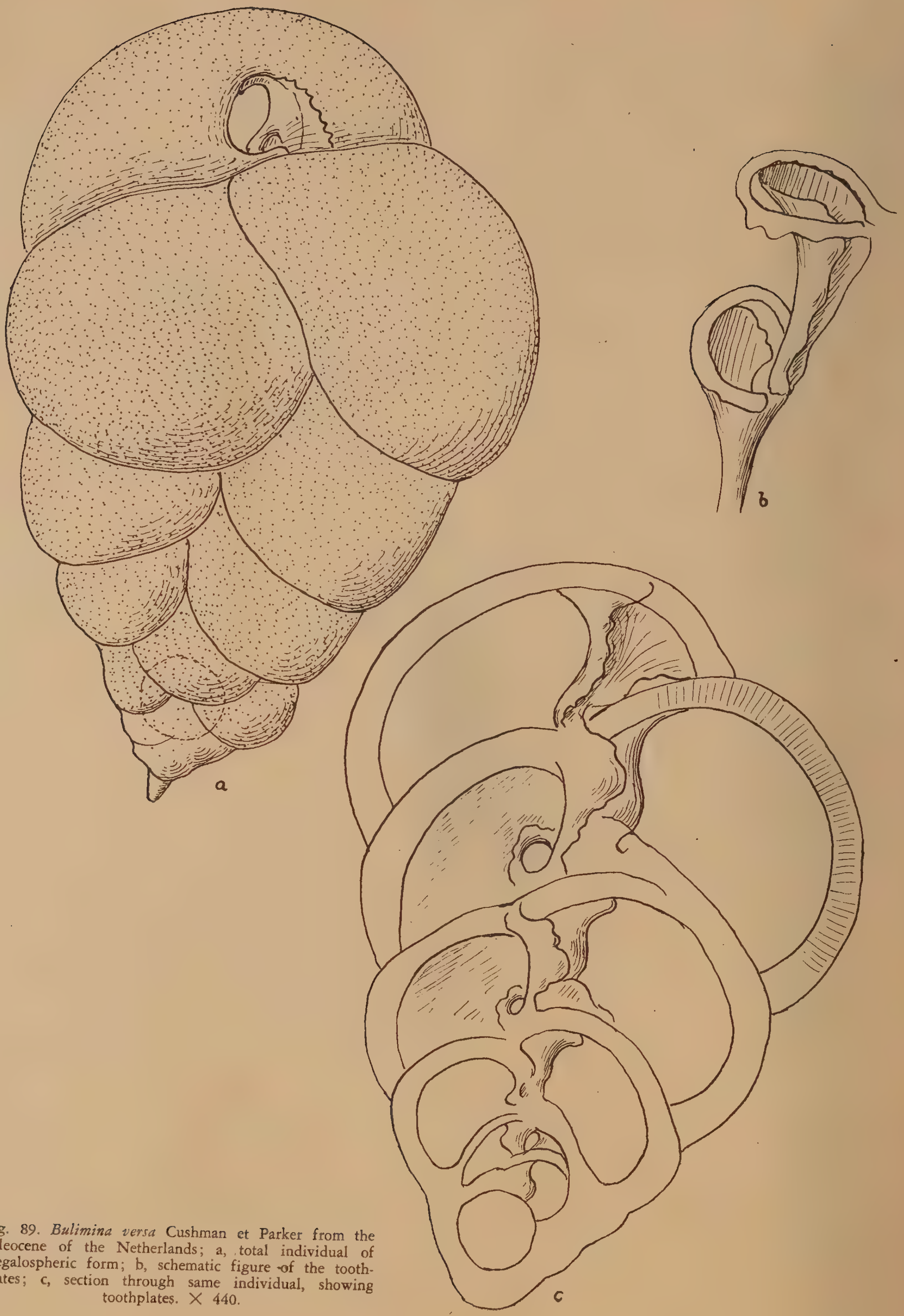

Fig. 89. *Bulimina versa* Cushman et Parker from the paleocene of the Netherlands; a, total individual of megalospheric form; b, schematic figure of the toothplates; c, section through same individual, showing toothplates. × 440.

The toothplate is interesting too. It shows a somewhat higher development than in *Bulimina debilis,* as here a basal hook with flaring free toothplate is formed. But on the other hand it shows not the high development of recent species. The tooth shows a fine sawed end which protrudes somewhat from the aperture. The aperture is simple and shows not the second aperture of the recent forms.

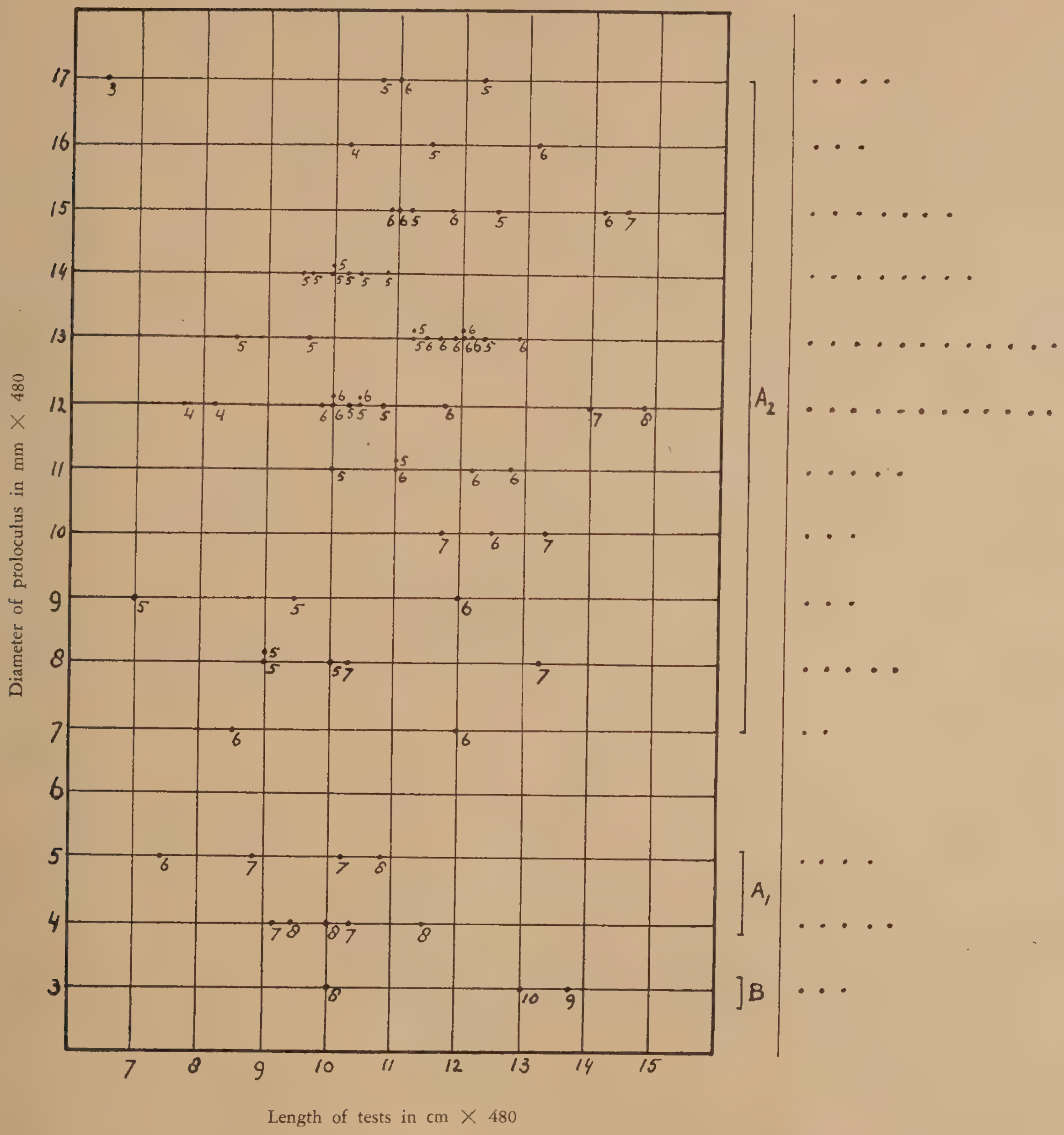

Fig. 90. Diagram showing relation between length of tests and size of proloculus of *Bulimina trigonalis* Ten Dam from the Paleocene of the Netherlands. The numbers added indicate the number of triserial rows of chambers.

The species was mainly found in those samples, which contained larger quantities of plant material, thus indicating, that this species lived on weeds and not on the bottom. The very thick,

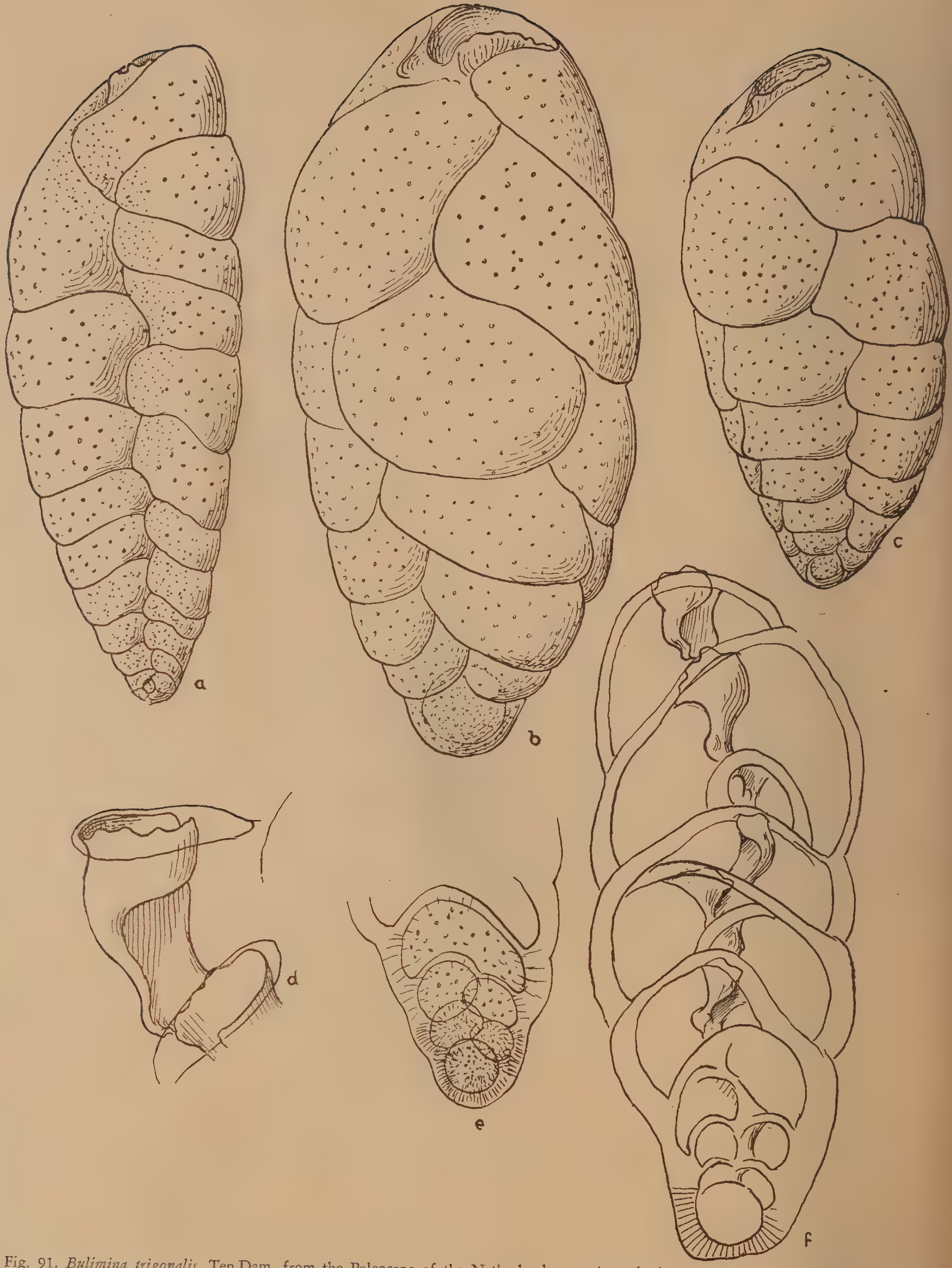

Fig. 91. *Bulimina trigonalis* Ten Dam, from the Paleocene of the Netherlands; a, microspheric specimen, showing straight rows of chambers; b. A_2-specimen, showing twisting rows of chambers; A_1-specimen, with straight rows of chambers. In a. the fine pores on the chambers are to be seen, in b and c those of the initial part; d, schematic drawing of toothplate; e, initial part of A_1, showing fine pores in the first, coarser ones in the next chambers; f, longitudinal section. × 440, except for d.

though hyaline walls indicate a species of shallow water. As no larger material of *Bulimina* was available from recent species, and as I wished to show how statistic data lie in a species of that genus, I got permission to publish them in this report. Here, as in *Bolivina* the B-form is, when adult, a large shell, but the A_1 is smaller, while the A_2-form gradually increases in size with the increasing of the size of the proloculus.

Bulimina aculeata D'Orbigny
(Figs. 92-94)

In my work on the Foraminifera of the Ammontatura (Publ. Staz. Zool. di Napoli, Vol. 12, 1932, p. 121-125) I met with the same difficulty of variating shells, Höglund found in his material of *B. marginata*. I then tried to prove, that *B. aculeata, B. buchiana* and *B. inflata* belonged to one and the same species, and that they were only different generations of *B. aculeata*. Now, with my knowledge of the inner structure of the tests, which at that time was not taken into consideration, I have come to the conclusion, that in the Ammontatura-material, which I restudied now, occurred at least two different species, viz. *B. aculeata* and *B. clava,* and that probably there occurred a third species too, which may be some form of *B. elongata.*

I restudied this material, and studied that of the Pacific, now at hand; statistic investigations showed, that it is possible to distinguish with exactness the three species *B. aculeata, B. clava* and *B. pagoda* by means of the distance of their pores and by the structure of their toothplates, and that the outer structure in these species is so variable (as shown by Höglund in *B. marginata*) that the outer structure cannot be chosen as characteristic.

Here I will give the results of my study about *B. aculeata* D'Orbigny.

Description of the test:

Test elongate or oval, more or less slender, tapering toward the oral end, with or without apical spine or spines, with or without spines at the basal part of the chambers. Chambers more or less inflated, later chambers mostly inflated. Aperture ovally rounded, with irregular collar, loop-shaped, with distinct second foramen and with dentated free tooth of the toothplate which runs even to the base of the foramen. Toothplate adjusted at the lower border of the former aperture, running curvedly toward the next one, here attaching itself along the protruding part of the aperture, and running along the border of the aperture, folding into a large free part with serrate free border, then once more folding its free flange into a narrow sipho which forms the second aperture at the base of the normal one. At the base of the plate this sipho ends near a more or less distinct hook, formed by the folding of the free border.

Spines in some specimens rather short, in others, especially those from deep water, very long, one long spine at each chamber.

Statistic statements:

B-form. Proloculus about 6 μ diameter. Mostly, but not always with terminal spine, in which the proloculus is found. Length from 0,27 up to 0,59 mm, breadth from 0,16 up to 0,28 mm.

A_1-form. Proloculus from 12 up to 35 μ. Most specimens without spine at apical end. Length from 0,26 up to 0,36 mm, breadth from 0,19 up to 0,26 mm.

A_2-form. Proloculus from 42 up to 45 μ diameter. All specimens without apical spine. Length from 0,21 up to 0,36 mm, breadth from 0,21 up to 0,36 mm.

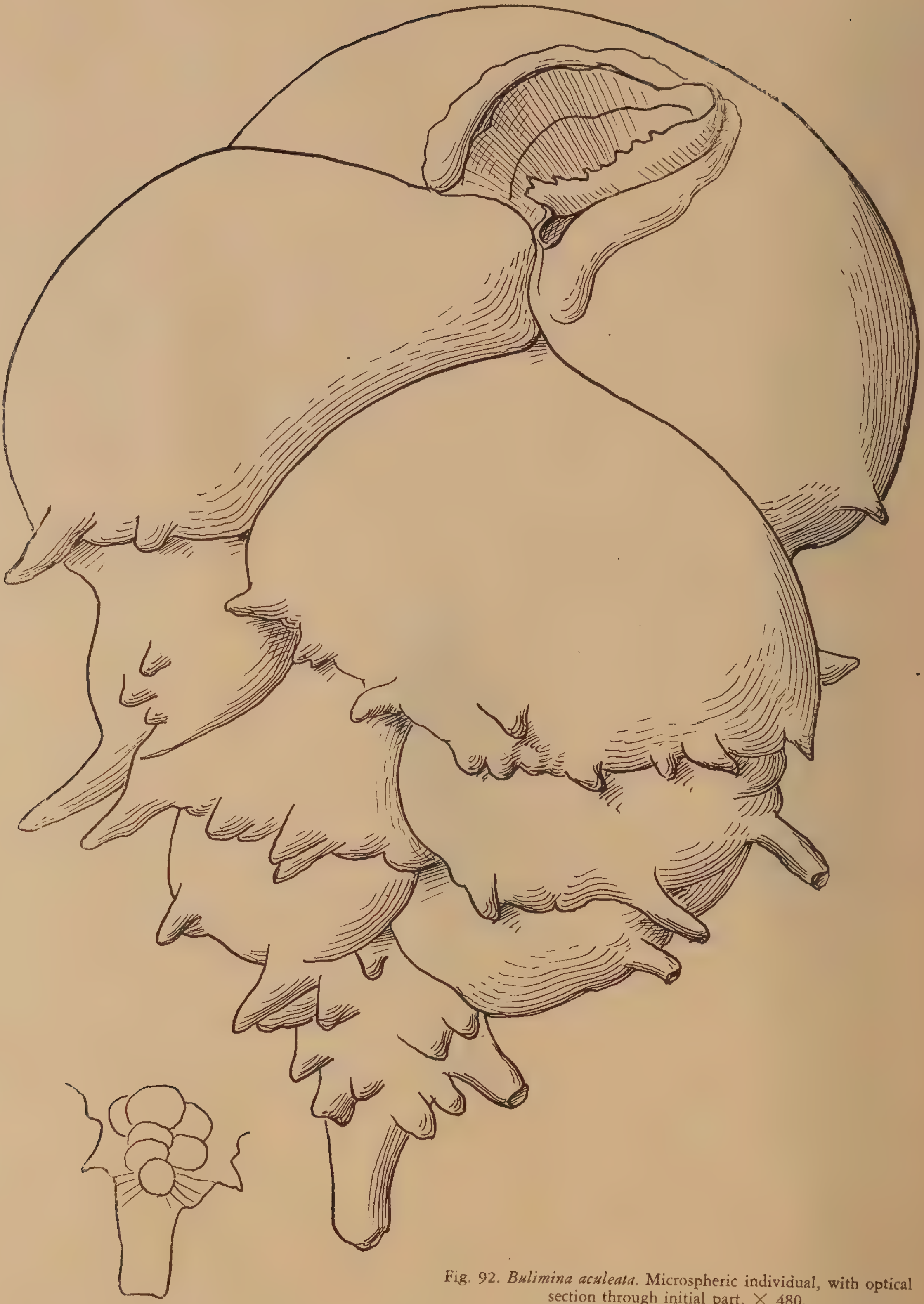

Fig. 92. *Bulimina aculeata.* Microspheric individual, with optical section through initial part. × 480.

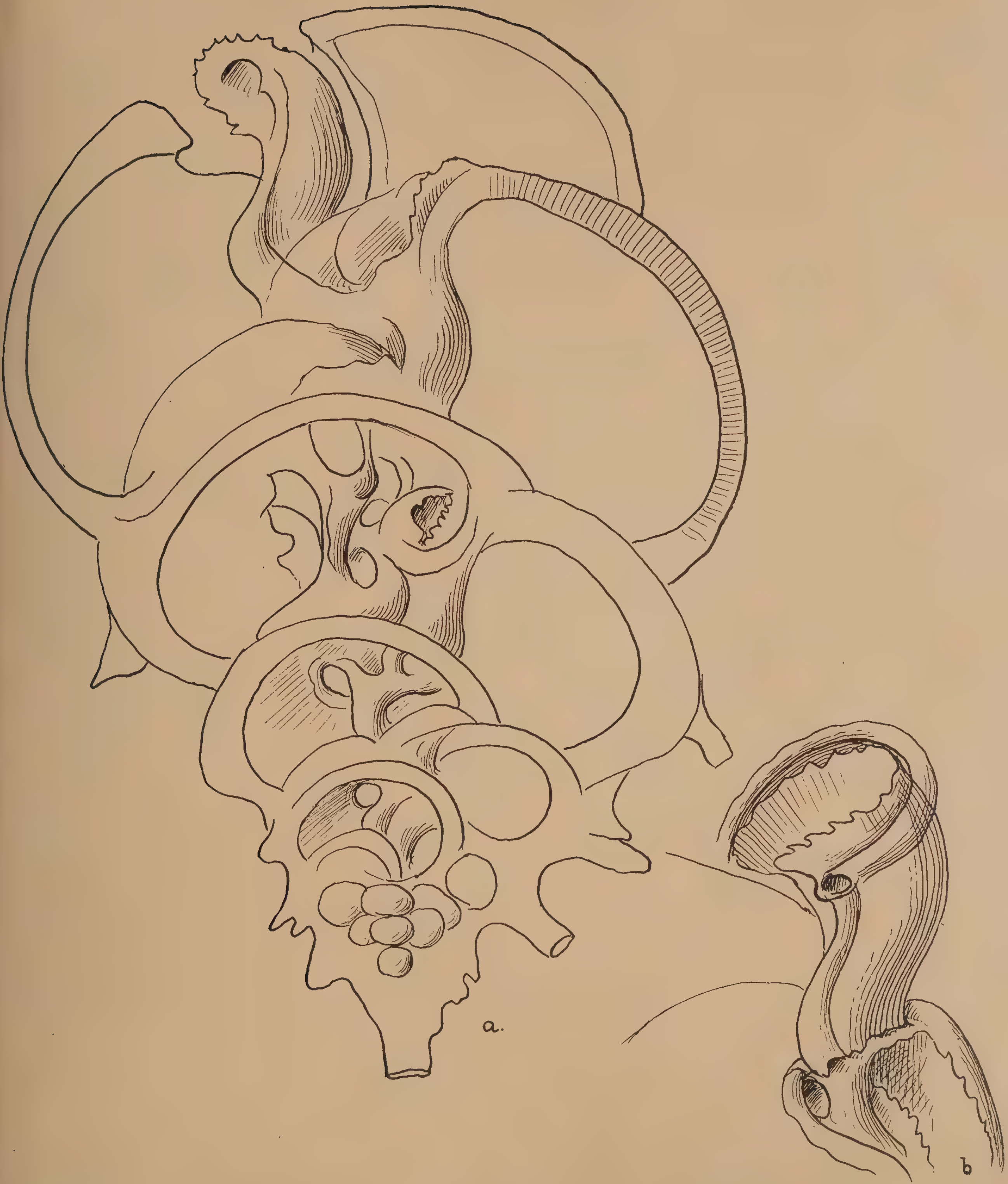

Fig. 93. *Bulimina aculeata*; a, section through the individual of fig. 92, × 440; b, schematic drawing of the toothplate.

Distance of pores covering the whole of the walls: 2 μ in average. This characteristic is very important, as in *B. marginata,* which often in outer features does resemble *B. aculeata,* the pores have a distance of about 4 μ, so that they give a much coarser impression.

Occurrence: In gatherings in the East of the Archipelago; depth from 300 up to 1015 fathoms.

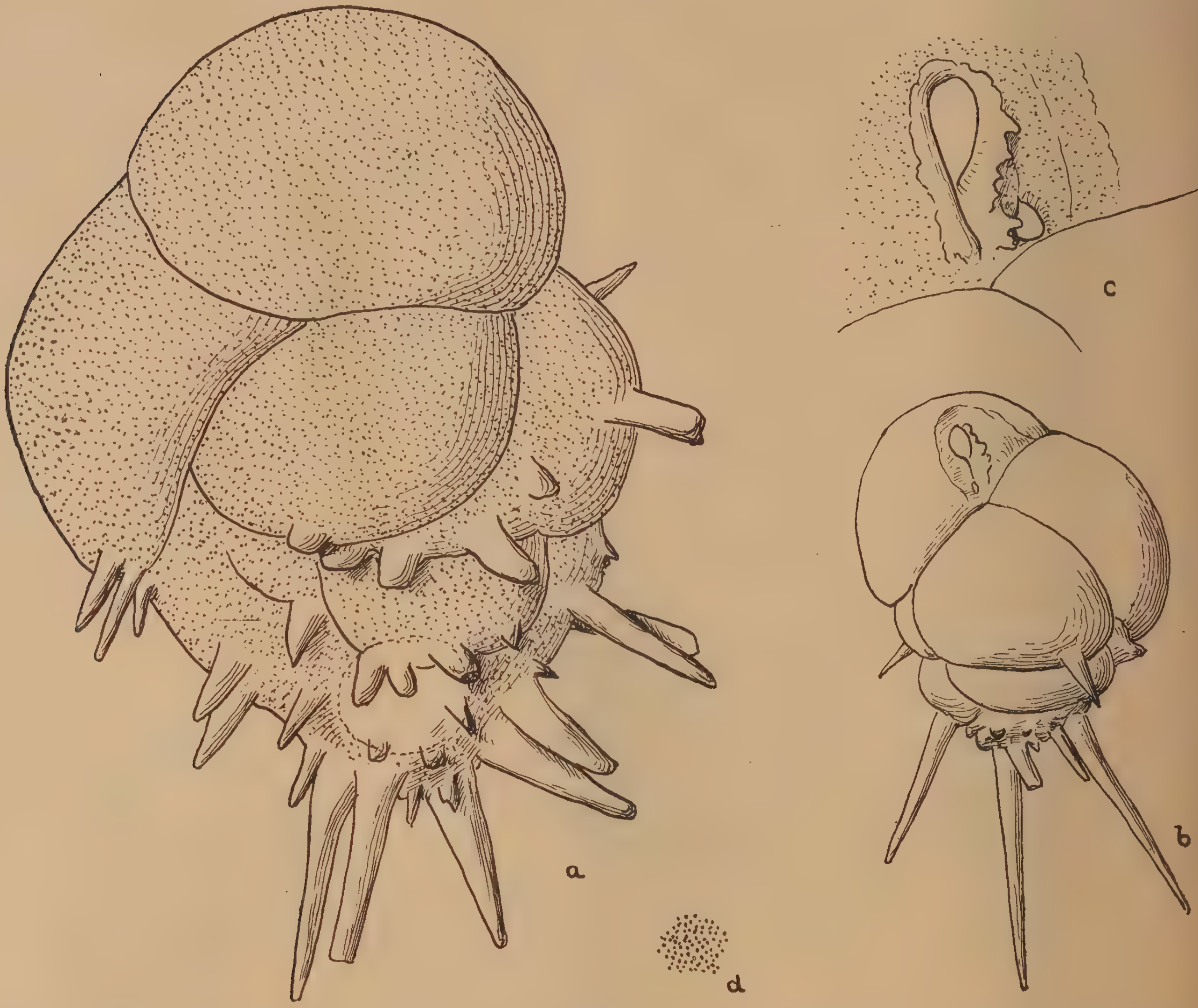

Fig. 94. *Bulimina aculeata*; a, megalospheric specimen (A_2) showing larger spines, × 480; b, megalospheric specimen from 1015 fathoms depth, with very large spines, × 100; c, aperture of the same individual, × 480; d, distance between pores of the specimen, mentioned under b, × 480.

Bulimina marginata D'Orbigny
(Figs. 95, 96)

The species is mainly recognisable by the sutural ridge of spines at each chamber. As those spinous ridges are directed toward the initial end, the chamber resembles the head of a toadstool, with inflated upper part and retracting part underneath. Deep under the ridge the sutures are found. The whole test is always tapering toward the oral end, as in all generations the chambers increase rapidly in size.

The species, which occurs in the Pacific, does in no means resemble that, which has been described by Höglund (l.c. 1947, p. 227-231, textfig. 205-217, pl. 20, figs. 1, 2; pl. 22, fig. 1). The specimens, which in the Malay Archipegalo seem to be scarce, and were found in the Mentawei Basin as well as in Savu Sea, showed more or less fine pores, thus standing somewhat between the *aculeata*-group and the *pagoda*-group. The chambers somewhat resemble those figured by Höglund in his fig. 207 and 214. Never they show the rounded chambers without spinous ridge, sketched in most of his other figures. Höglund describes extremely fine pores, while in the Pacific the pores are not extremely fine, though not coarse. The aperture in the Pacific specimens always shows a dentated collar, which is not found in the Norvegian specimens. Yet in his fig. 2 on pl. 20 he figures a free tooth with sawed end, which is in agreement with the Pacific specimens. So it may be, that the species shows some variation in respect to these characteristics, it may be also, that the species found in the Pacific is a different species. Höglund says about this variability: "This is an especially variable species as is shown in figs. 205-217, where a number of different variations is demonstrated in outline drawings. These represent a series leading from the most spiny individuals agreeing with Brady's *B. aculeata* and Williamson's *B. pupoides* var. *spinulosa* by way of specimens with only slightly crenulated chamber edges, nearly corresponding to D'Orbigny's type-specimen of *B. marginata*, to specimens whose armament is nothing more than an apical spine conforming, for example, to Brady's fig. 3 (pl. 50 in the Challenger Report) of *B. elegans*. All the forms of variation occur promiscuously, without the slightest descrimination in the different gatherings. This manner of occurrence, together with the fact that they are all exactly similar to each other as regards the aperture and the internal structure, proves beyond all doubt that the entire series belongs to one single species."

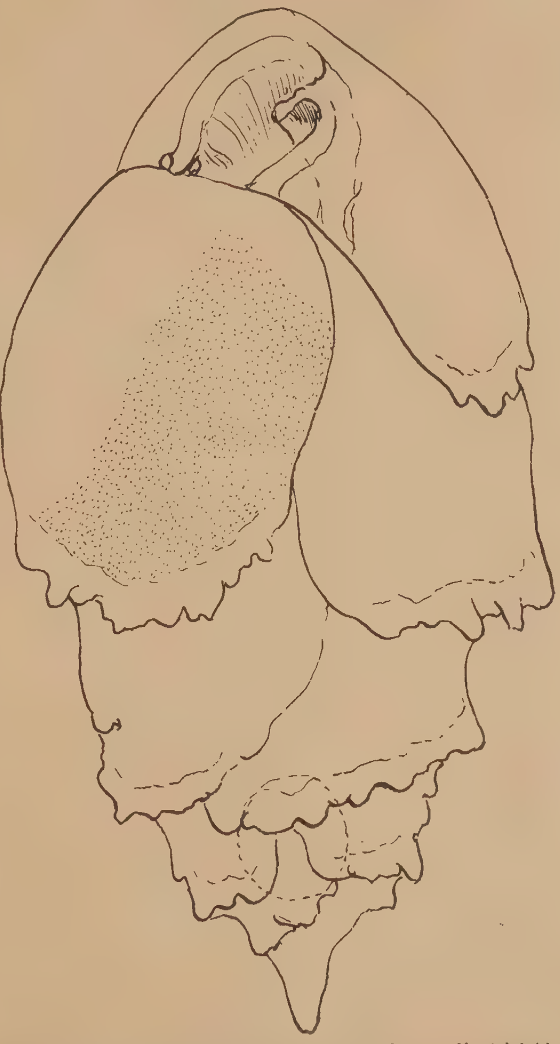

Fig. 95. *Bulimina marginata*; specimen from off Adelaide, showing typical characters of the species; × 480.

It is remarkable, however, that the Pacific specimens, always rare as they may be, from very different localities are quite invariably belonging to the type, which is shown in his figure 207.

My investigations about the structure of the toothplate agree with those, found by Höglund, though his description is somewhat superficial. The aperture is loop-shaped, with one higher border with collar, while along the more sunken border runs the free tooth of the plate which shows a typical serrated tooth. But at the lower end of this tooth the plate is once more folded up, and forms underneath the obliquely running upper border of the aperture a distinct second foramen.

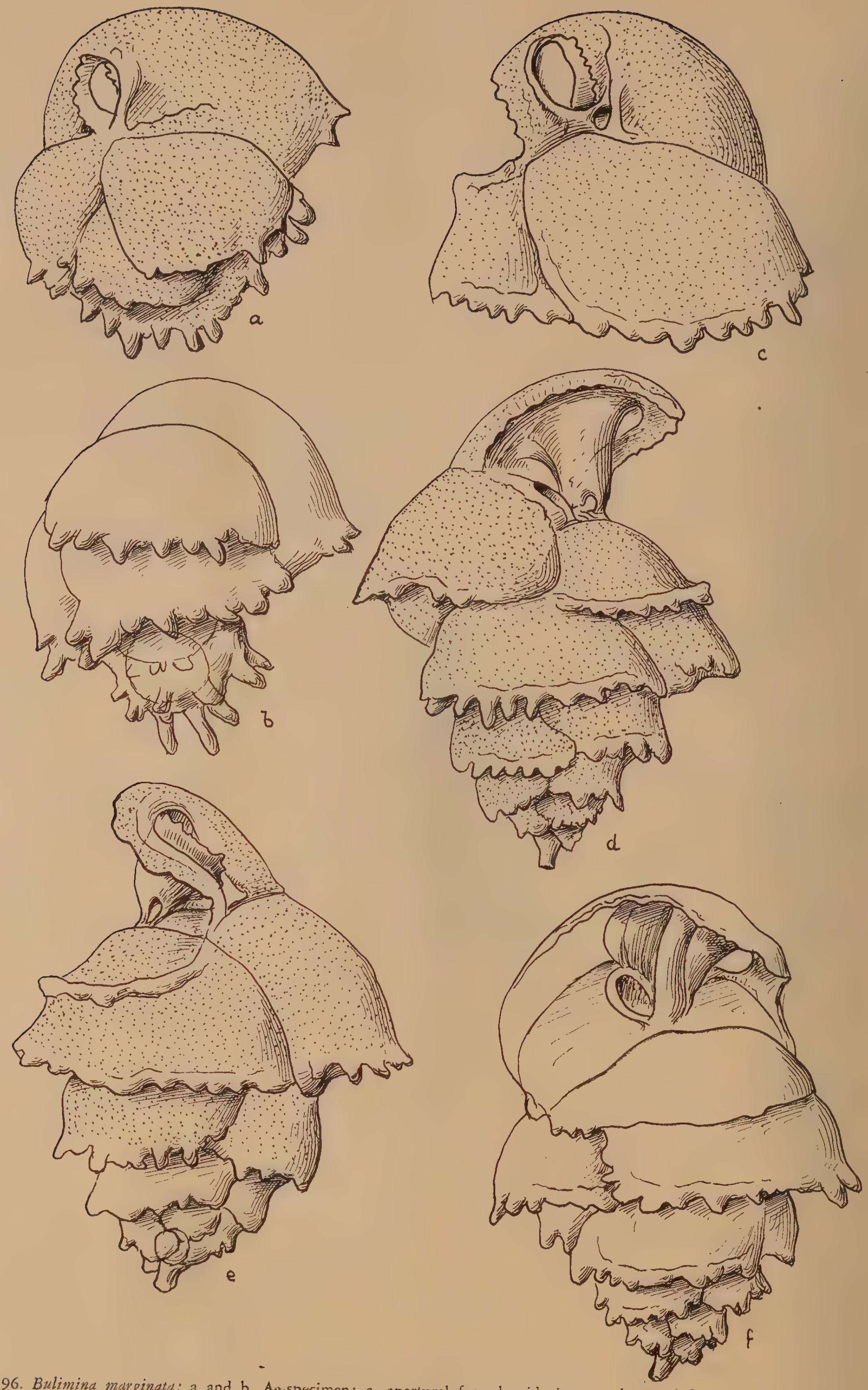

Fig. 96. *Bulimina marginata;* a and b, A_2-specimen; a, apertural face, b, sideview; c, d, e and f, A_1-specimen, from which part of last chamber is broken away, views from different sides, a and c apertural face. × 390.

This second foramen runs as a sipho along the free folded border of the plate and opens at the base of the toothplate near its adjustment at the base of the former aperture, at the backside of the plate. Thus the plate shows a much higher complicated structure than those of fossil forms, such as *B. versa* and *B. trigonalis.*

In this way *B. marginata* may stand near *B. aculeata,* as in the latter the toothplate likewise shows these complications, while the pores of *B. marginata* are rather finer than those, found in *B. pagoda* and its allies.

The species may be in some cases confused with *B. aculeata,* but it is clearly distinguishable from *B. clava* by the much coarser pores of the latter species.

The species is rather rare in the Archipelago, and was found at St. 8° 30′ S., 116° 51′ E., depth 290 fathoms, 2° 17′ S., 99° 56′ E., 613 fathoms and 2° 26′ S., 99° 35′ E., 582 fathoms. It may be, that some specimens were rather *B. barbata* Cushman.

Bulimina rostrata Brady
(Figs. 97, 98)

Cushman believes (U.S. Nat. Mus., Bull. 161, 1942, p. 10) that his *Bul. buchiana* in U.S. Nat. Mus., Bull. 104, p. 95, 1922 is a synonym of *B. rostrata.* His *B. buchiana* does exist in the Pacific gatherings, as I have proved dealing with this species, and *B. rostrata* is quite a different species of this genus. For, in *B. buchiana* the length if the shell is much more than in *B. rostrata,* and the structure of the costae is different. (*B. buchiana* was recently called *B. pagoda* by Cushman).

In *B. pagoda* the costae are formed by the spines, and are rather thick; in *B. rostrata* the costae are spinous too, but are always very thin and very hyaline. In *B. pagoda* the length of the shells is up to 0,67 mm, while in *B. rostrata* the length of most individuals is about 0,20 mm, a single microspheric specimen measured up to 0,30 mm. While in *B. pagoda* the front-part of the chambers is always porous, that of *B. rostrata* lacks its pores totally, and only the sides of the chambers show pores. In both species the form of the aperture is similar.

Cushman's definition of the species runs as follows:

"Test small, fusiform, often somewhat curved, broadest near the middle, rounded at the apertural end, pointed at the initial end; chambers indistinct; sutures indistinct, occasionally showing slightly between the costae, slightly depressed; wall of last chamber smooth, rather coarsely perforate, remainder of test ornamented by ten or eleven regular, platelike costae, continuous throughout; aperture small, loop-shaped, at the apex of the test. Length (of figured specimen), 0,40 mm; diameter 0,20 mm" 1).

I must add to this description, that the costae are not so regular as is mentioned by Cushman, but that they show at the sutures of the chambers, directed towards the initial part of the test, a denticulation which in some cases is spinous. The pores, as mentioned already, are confined to the sides of the chambers. thus, near the sutural ends toward the apertural end of the shell there are no pores visible. The aperture never is loop-shaped, but nearly oval.

The B-generation, represented by 3 specimens in the material (the species occurs as well in the

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1) This definition is unaltered given in Cushman's exhaustive treatise on the Buliminidae (Bulimina and related Foraminiferal genera, U. S. Dep. of the Interior, Geol. Surv. Prof. Paper 210, D, 1947, p. 124).

neighbourhood of Sumatra as in that of Flores) begins with a proloculus of only 6 μ diameter, and 6 rows of three chambers are added. The costae in this generation are smooth, and without real spines,

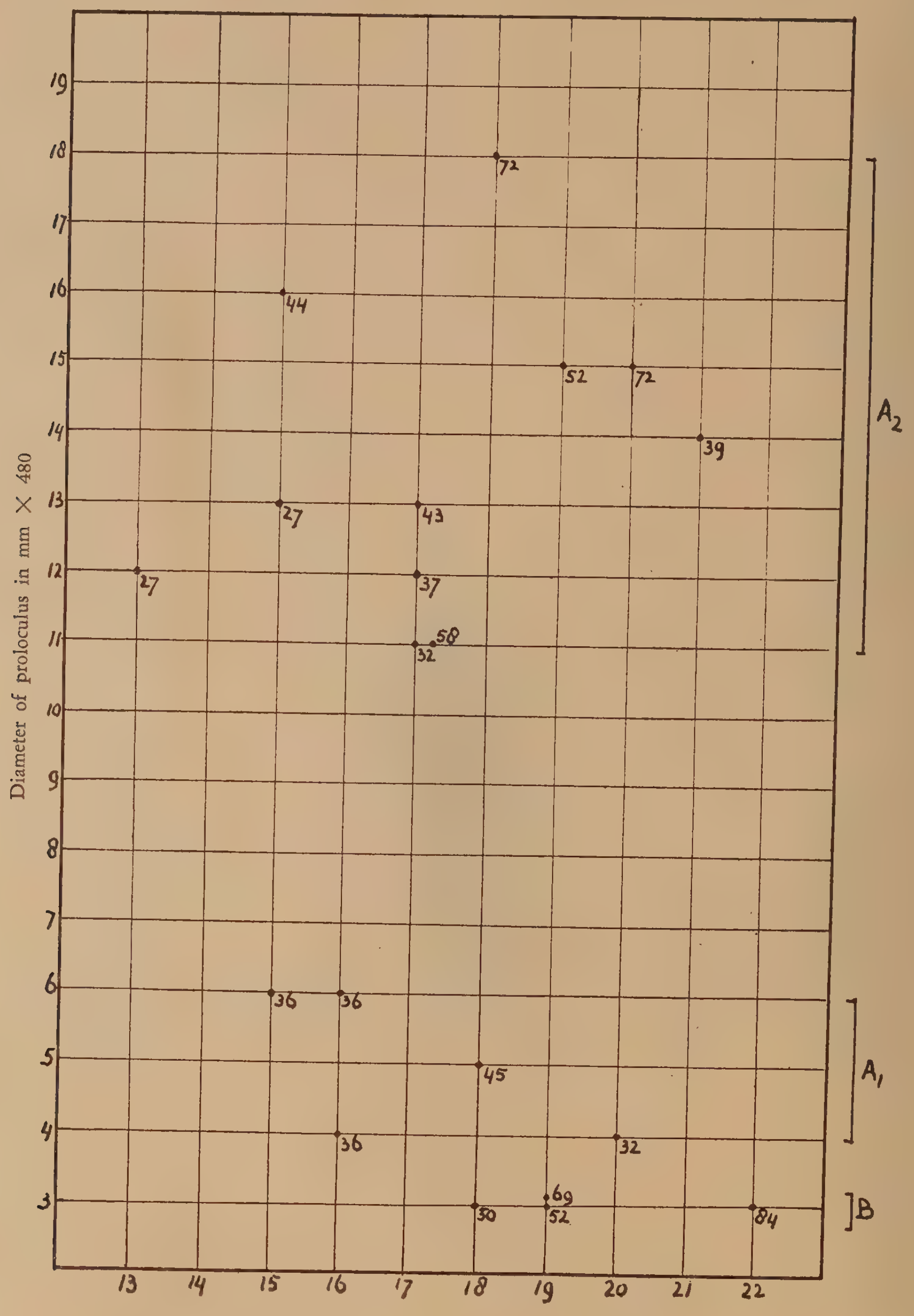


Fig. 97. *Bulimina rostrata.* Diagram, showing relation between diameter of proloculus and ratio length to breadth of tests. The figures added indicate the product of length and breadth, and thus give an idea of the volume of the tests. The diagram shows, that the volume of B-tests is in average the larger one, while that of A1-tests is much smaller, even smaller than A2-individuals. It seems to be a rule in Buliminine and other toothplate-Foraminifera, that individuals of A1 are smaller than those of the A2-generation. Even the added figures give a striking index to distinguish A1 form B, which, when a simple frequency-curve would have been given, would have been quite impossible.

except for the initial part. Length about 0,28 mm in the adult, breadth up to 0,14 mm. Length: breadth as 2 : 1.

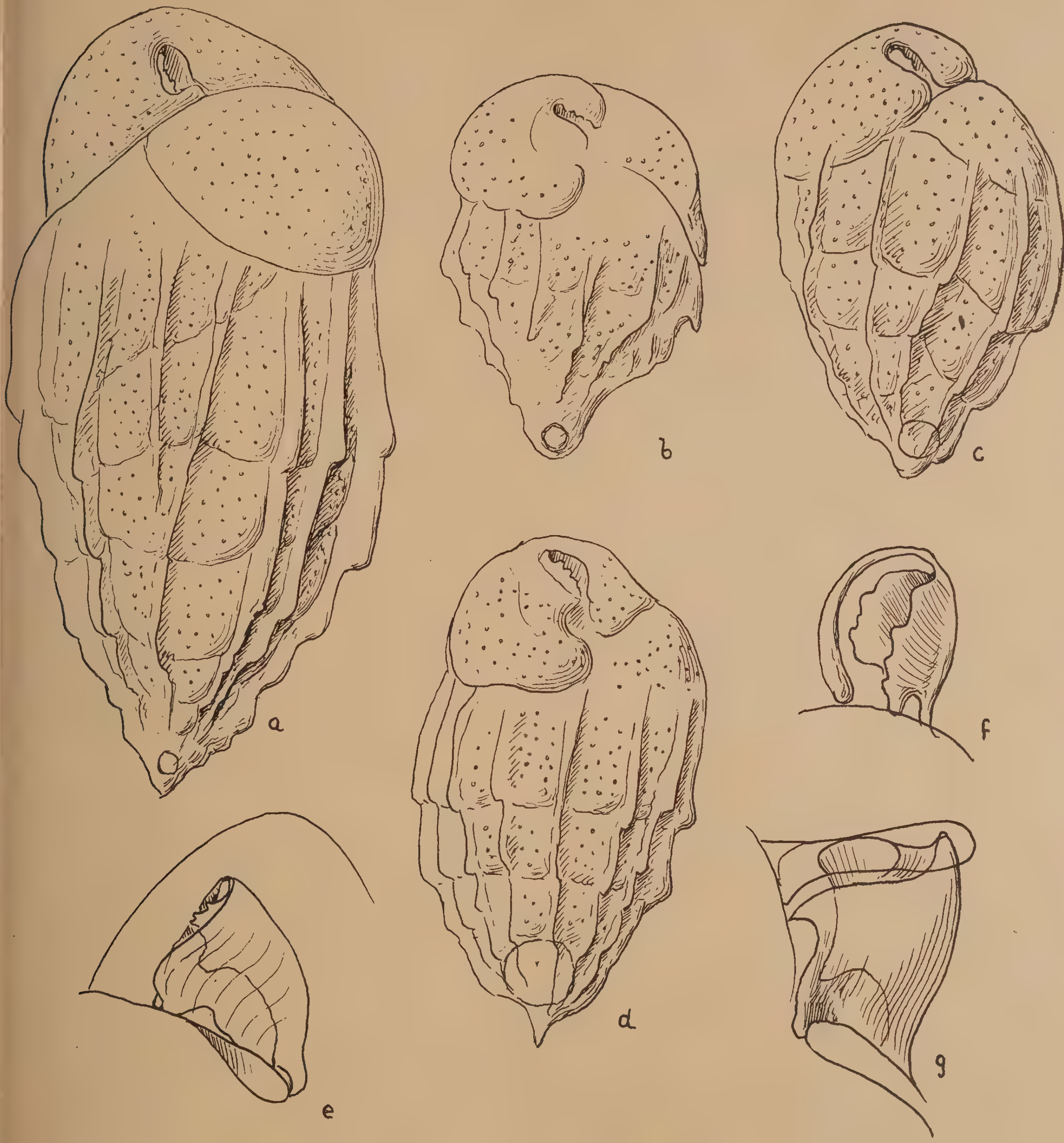


Fig. 98. *Bulimina rostrata.* a, Microspheric specimen; b, and c, A$_1$-specimens; d, A$_2$-individual. All × 480. e, f, and g, different views of toothplates, × 630.

A$_1$-generation. In this generation the costae are rather spinous. The proloculus has a diameter from 9-13 μ, and only 4-5 rows of chambers are added to it. Length from 0,15 to 0,20 mm, breadth 0.10 mm; length: breadth 1,7 : 1.

A_2-generation. Here the costae are irregular with spinous outgrowths near the sutures, and always there is a short spine at the initial end. The proloculus-diameter ranges from 23 up to 30 μ, and is followed by 3-4 rows of three chambers. Length 0,12 to 0,21 mm, breadth 0,09 to 0,11 mm. Length: breadth as 1,7 : 1.

The toothplate is of the typical buliminine type, running from the dorsal end of a foramen towards one of the sides of the next, and forming a projecting lip-like side of it. The free part of it is curved and forms a free, tentated tooth in the aperture, which tooth, however, is not very conspicuous. The part of the toothplate which forms the side of the next aperture is involuted and forms a second small foramen besides the normal one, as is a rule in *Bulimina.* It does not differ very much in shape from that of *B. pagoda,* thus indicating that these two species, which can easily be distinguished statistically, are closely related.

The species was found in the stations:

8° 15′ S., 118° 56′ E., depth 340 fathoms;
10° 00′ S., 123° 19′ E., depth 453 fathoms;
2° 26′ S., 99° 35′ E., depth 582 fathoms;
2° 17′ S., 99° 27′ E., depth 377 fathoms;
2° 6′ S., 99° 54′ E., depth 778 fathoms.

Bulimina pagoda Cushman
(Figs. 99, 100)

This species, which shows a very high variability in respect to its outer form, can be distinguished from *B. aculeata* by the larger distance of its pores, the direction of the spines being always toward the apical end and nearly parallel to the axis of the shell, and its different mouth and toothplate.

Description of the test:

Test more or less elongated, always tapering towards the oral end, with or without apical spine. The last-formed chambers mostly higher than broad, which feature is characteristic. Spines only around the basal part of the chambers, in a single horizontal row, never being the end of longitudinal ridges on the surface. Aperture in younger specimens loop-shaped and rounded, in older ones elongate up to the top of the high chamber; with distinct collar and somewhat protruding free border of the toothplate along the sunken side of the aperture. Second foramen at the base of the aperture, narrow but distinct. Free end of tooth lobulated, not with sharp denticulations. Toothplate adjusted at one of the sides of the former aperture, then running up toward the next aperture with a sigmoidally curved back. The free border of it once more is folded, forming a narrow sipho, ending into the second foramen, and beginning with a more or less distinct hook, as in *B. aculeata.* But the free border of the tooth shows not the sharp sawings of *B. aculeata,* but only undulations.

Statistic statements:

B-form. Proloculus about 6-8 μ diameter. Sometimes with longitudinal ridges on the surface, but not always. Length 0,27 up to 0,67 mm; breadth from 0,17 up to 0,37 mm.

A_1-form. Proloculus from 10 up to 18 μ diameter. Longitudinal ridging never distinct. Length from 0,29 up to 0,43 mm, breadth from 0,21 up to 0,25 mm.

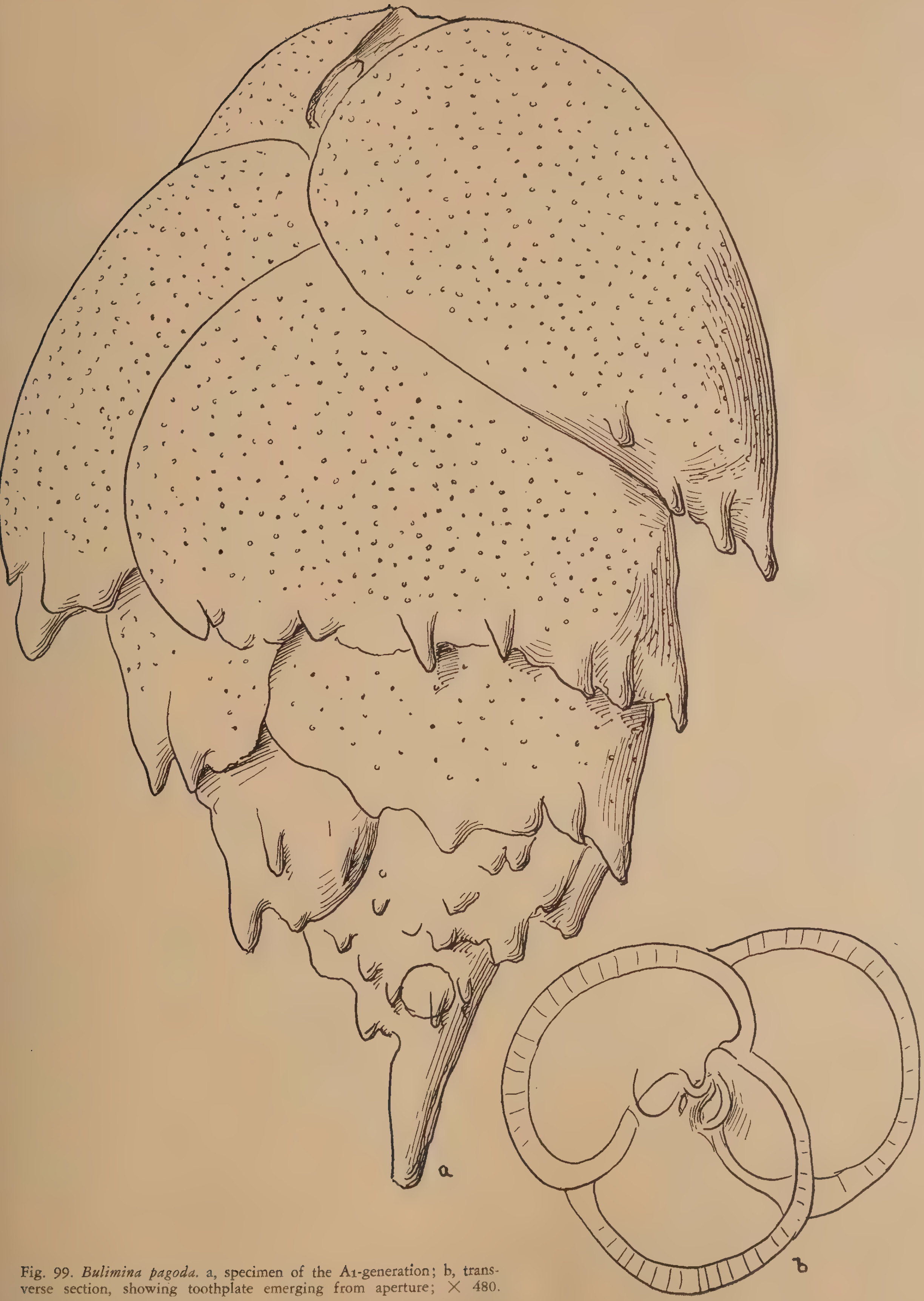


Fig. 99. *Bulimina pagoda.* a, specimen of the A1-generation; b, transverse section, showing toothplate emerging from aperture; × 480.

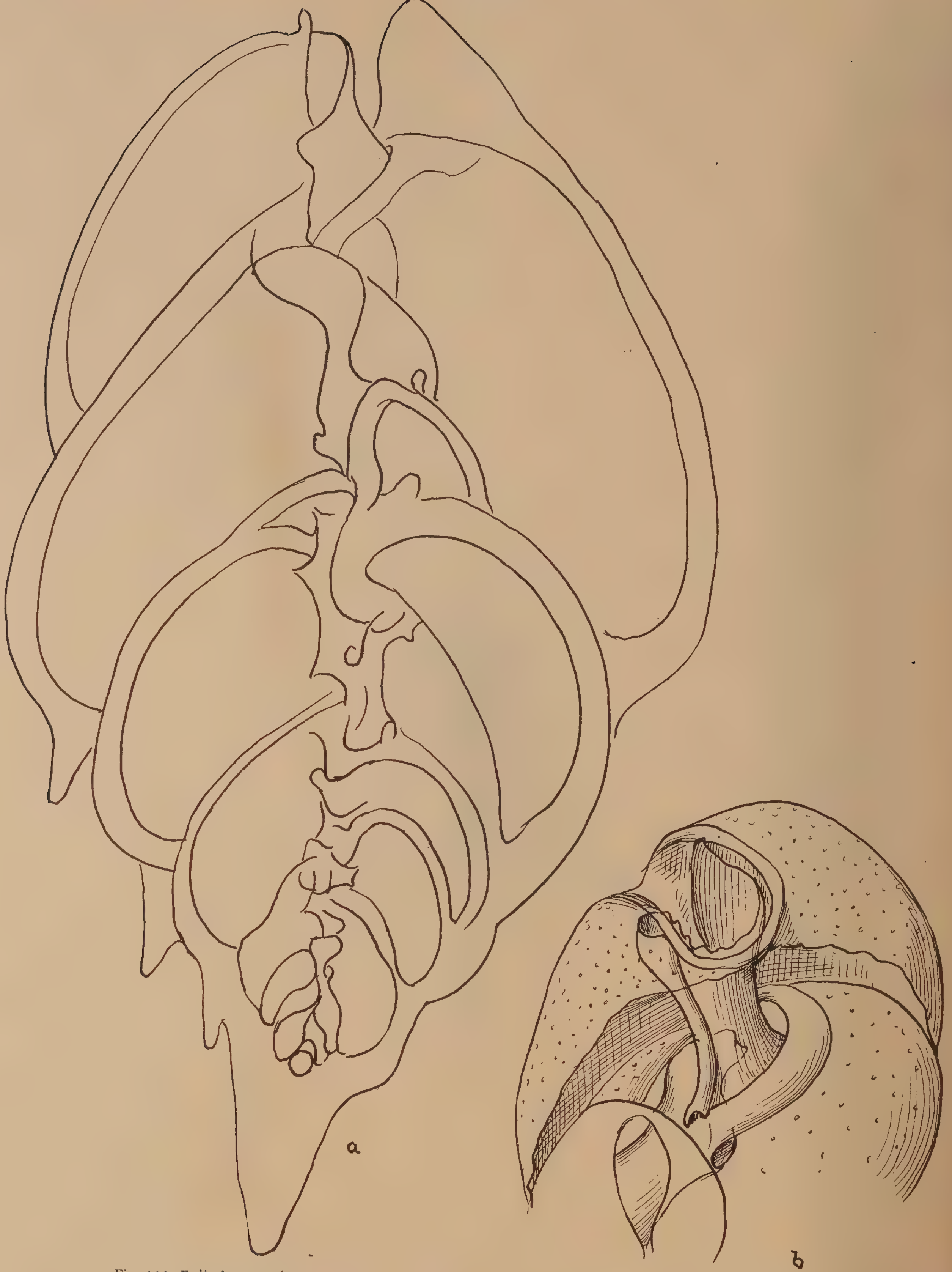


Fig. 100. *Bulimina pagoda.* a, Microspheric specimen, × 480, section; b, Schematic drawing of toothplates.

A_2-form. Proloculus from 29 up to 35 μ diameter. Length from 0,19 to 0,37 mm, breadth from 0,15 up to 0,27 mm.

All generations show at least an indication of an apical spine, most prominent in the B-form.

Occurrence:

Only in gatherings from the Mentawei Basin, from 582-826 fathoms.

Distance of pores: average 3,1 μ. Often the pores are somewhat coarser than in most other species of the *Buliminae.*

I maintained the name *B. pagoda,* though Cushman stated, that d'Orbigny's species has nothing to do with this recent material; as may be clear from the recently appeared paper of Cushman's (1947, Geol-Survey prof. paper 210-D) several other recent forms may be more or less identical with the species, described here fully. They are *Bulimina clava* Cushman et Parker, but the species here does not show costae, which are described for *clava*, and *Bulimina pagoda* Cushman. For the latter species Cushman gives the following analysis (p. 126-127): "Test rapidly tapering, broadest near the apertural end, almost as broad as long; consisting of as many as 5 whorls; chambers distinct, deeply cut under at the base, inflated, especially those of the last whorl, increasing rapidly in size as added; sutures of the last whorl distinct, depressed, the position of the earlier sutures clearly defined by the sharp undercutting of the chambers; wall of the periphery of each chamber with a series of large, stout spines projecting outward and curving downward, otherwise smooth, thin, rather coarsely perforate; aperture very slightly comma-shaped, at the apex of the test, well above the junction of the second and third chambers. Length 0.50 mm, diameter 0,40 mm."

This description agrees in all points with that, given above. So the species found here is identical with Cushman's *B. pagoda.*

Bulimina clava Cushman et Parker
(Figs. 101-104)

This species is not so variable as *B. marginata, B. aculeata* and *B. pagoda,* as its outer form, at least in the megalospheric forms, is always rounded; in the B-form only an apical spine can be found. At the basal part of the chambers a row of short spines forms the ends of distinct longitudinal ridges along the surface of the chambers. In *B. pagoda* these ridges are found too, but by all means not so distinct, while in *B. costata* they run unbroken over the whole length of the shell. In *B. clava* the chambers always are much broader than high and this may be another difference with *B. pagoda.* The shell-walls are always very thick, but very hyaline too, caused by the large distance between the pores. Aperture a very widely rounded opening, surrounded by an indistinct collar. The free part of the toothplate forms a not-protruding tooth which shows only slight undulations at its free end. The free end runs totally along the lower border of the mouth, and forms a small inconspicuous second foramen; at the base of the toothplate the beginning of the sipho, which leads to this foramen, is indicated by a prominent hook. Thus the toothplates of *B. clava* and *B. pagoda* are very much alike, so that it may be, that these two species are only varieties of each other. But in *B. clava* the distance of the pores is much larger than in *B. pagoda.*

Statistic statements:

B-form. Proloculus 6 μ diameter. With apical spine. Length from 0,24 up to 0,61 mm, breadth from 0,35 up to 0,37 mm.

A1-form. Proloculus from 10 up to 23,7 μ diameter, often with endspine. Length from 0,27 up to 0,52 mm, breadth from 0,21 up to 0,32 mm.

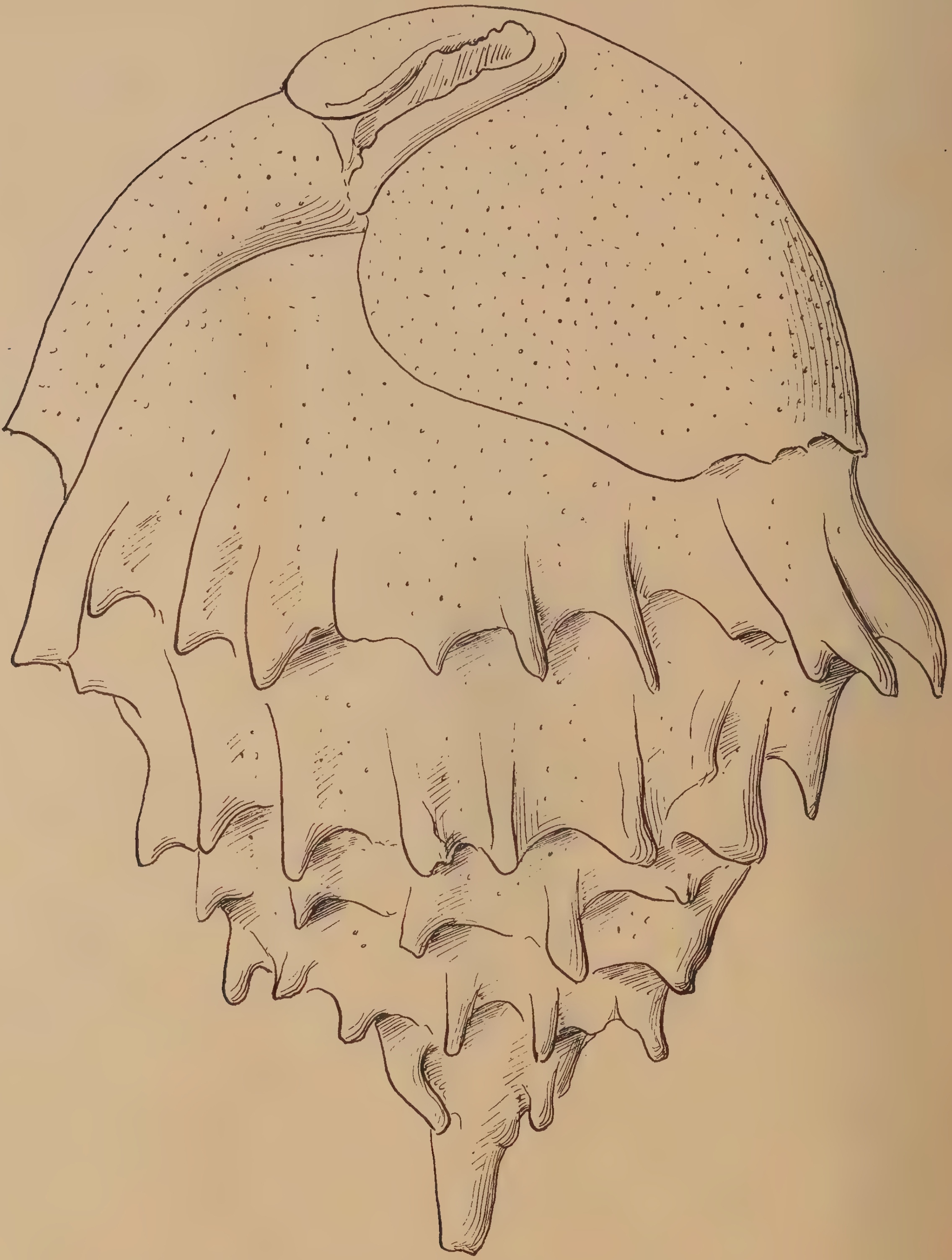


Fig. 101. *Bulimina clava.* Microspheric specimen, or A1; × 480.

A_2-form. Proloculus from 66 up to 83 μ. Length from 0,21 up to 0,50 mm, breadth from 0,20 up to 0,41 mm.

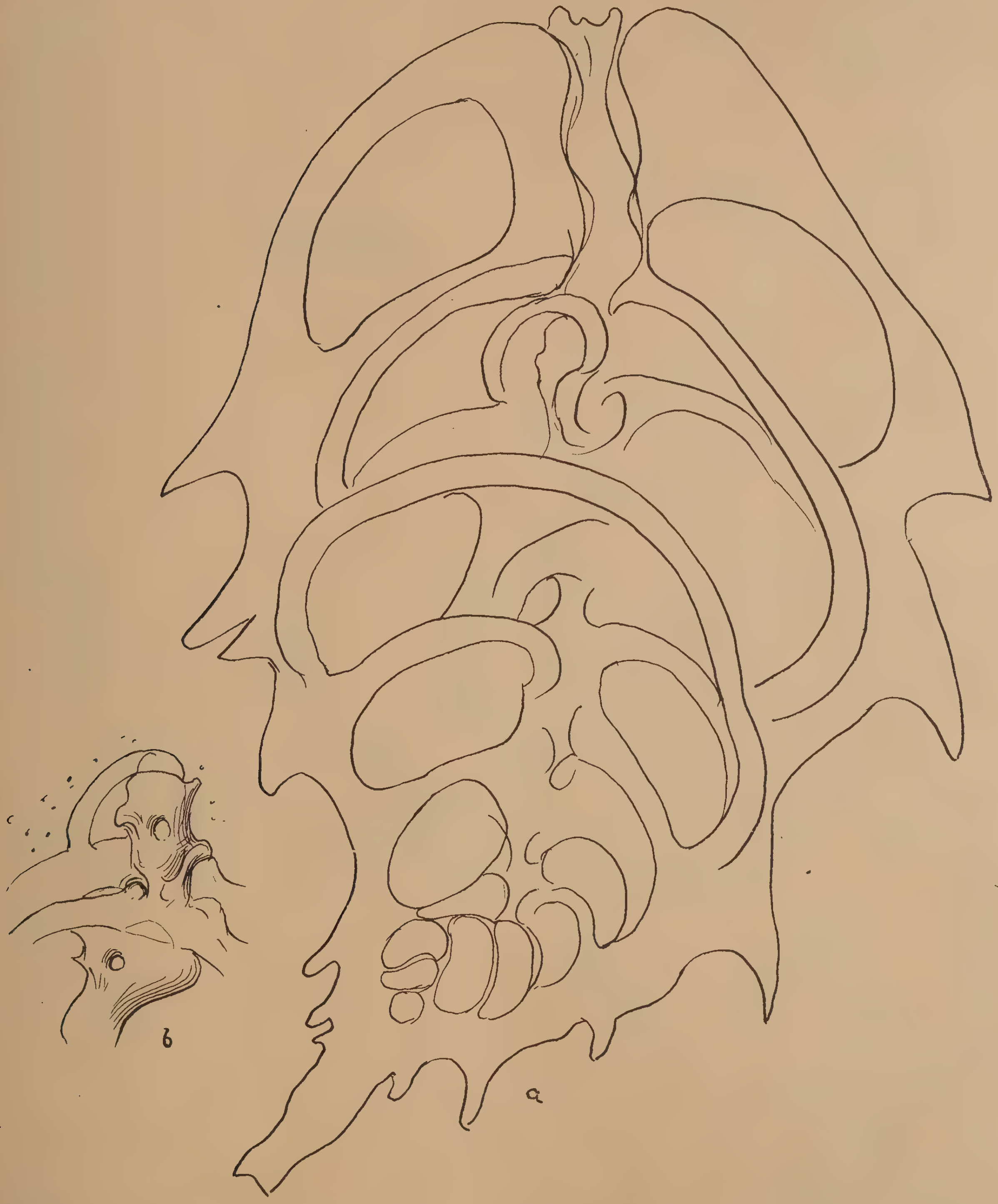


Fig. 102. *Bulimina clava.* a, Longitudinal section though specimen of figure 101; b, toothplates; × 480.

Distance of pores about 6,2 μ.

Occurrence: This is the commonest *Bulimina* in the Archipelago, found as well in gatherings in the western as in the eastern part of the Archipelago, from 330 up to 826 fathoms depth.

The description by Cushman (1947, Geol. Survey Prof. paper 210-D) is as follows:

"Test large, tapering, greatest width formed by the last whorl, initial end pointed, typically with a stout spine, three or four whorls in the adult test, the last whorl making up more than half the surface; chambers of the earlier portion obscured by the sculpture of the surface, inflated, those of the last whorl distinct, the basal margin distinctly under cut; sutures of the last whorl distinct, slightly depressed; wall finely but distinctly perforate, in the last chambers nearly smooth on the upper part, becoming costate toward the periphery, each costa extending backward into a spinose process, the costae of adjacent chambers in the earlier part often fused; aperture broadly commashaped. Length up to 0,90 mm, diameter up to 0,50 mm."

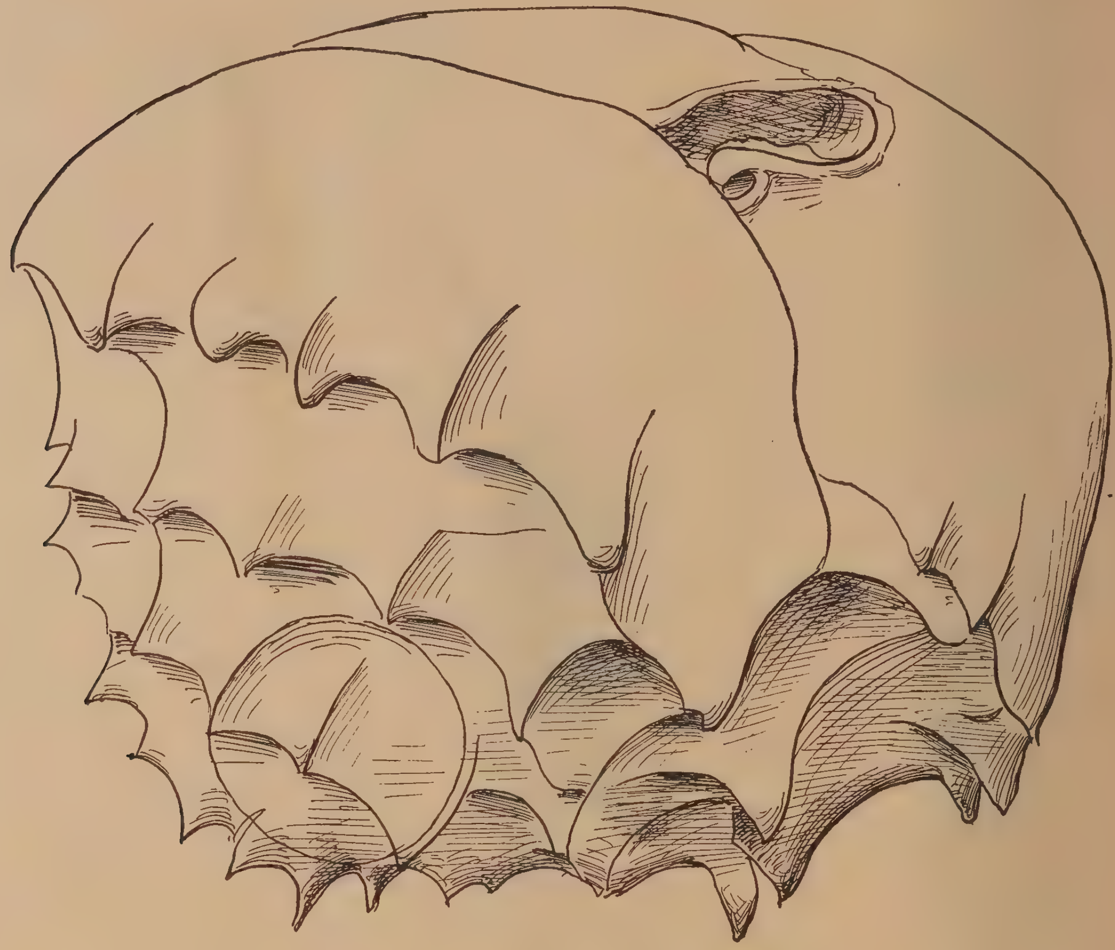


Fig. 103. *Bulimina clava.* Megalospheric specimen (A_2), with megalosphere sketched; × 480.

The species has been described formerly by Cushman as *B. inflata.* Only a study of the toothplate of both recent and fossil species (by Seguenza) can solve the question of their presumed identity.

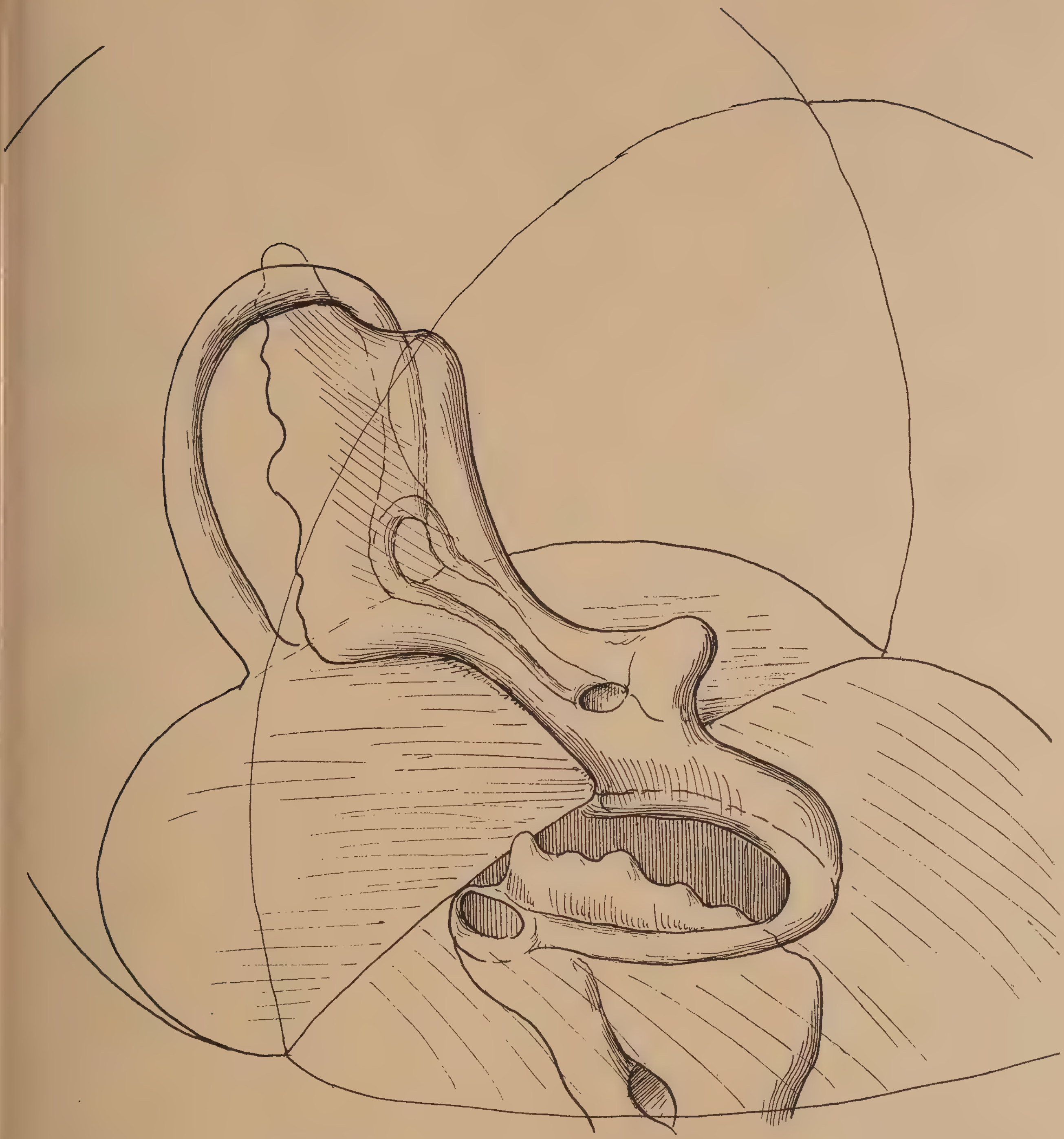


Fig. 104. *Bulimina clava*. Schematic figure of toothplates, showing the sipho which leads towards the secundary aperture.

III Genus **Reussella**

This genus has developed from buliminine forefathers in the Upper-Cretaceous, where typical triangular bulimine species can be traced, though we do not know yet their inner structure, which may reveal them to be quite other forms. The whole group of recent *Reussella* seems to possess very coarse pores, and is in this way a step further in the development of coarse pores in the family of the *Buliminidae,* whose primitive species always have very fine pores.

In this genus the difference with typical *Bulimina* is found in the triangular form, together with the coarser pores. In the sub-genus *Chrysalidinella* the triserial chambers are followed by uniserial ones, and it is very remarkable that in later chambers the toothplate is lacking totally, as in the parallel series of *Uvigerina-Rectuvigerina* and *Bolivina-Rectobolivina* the toothplates remain. But in *Chrysalidinella* the oral wall is also totally different from that of *Bulimina,* as the normal aperture is obliterated and replaced by irregular larger pores, obviously caused by resorption. In the first sets of chambers the normal mouth and the normal toothplates are found, and they lead to the conclusion, that this subgenus is an offspring of real *Reussella.*

As I do not believe in the necessity of establishing different genera for those forms in the groups of *Bolivina* and *Uvigerina,* which show uniserial arrangement in the endstages of the test, and as I only will consider them as sub-generic names, I believe it best, to call *Chrysalidinella* a subgenus of *Reussella* too, the only difference being the uniserial arrangement of the chambers in the end-stages of the test.

Reussella is known from the Cretaceous upward; *Chrysalidinella* seems to begin in the Miocene; this is in agreement with our view, that *Chrysalidinella* is an offspring of *Reussella.* In his publication (Foraminifera; special publ. Lab. For. Research, No. 1, 1928, pl. 37) Cushman gives the suggestion. that *Reussella* may be derived from a type like *Bulimina elegans* D'Orbigny. I believe him to be quite correct in this suggestion, as *B. elegans* belongs to the group with coarser pores, which find their development even in the Miocene strata.

In a recent paper Cushman and MacCulloch have given descriptions of some recent species, one of which has been described here also (*R. aequa*). The authors describe a totally rounded aperture which does not coincide with the aperture, mostly found in *Reussella.* I could not state this description of the aperture in *R. aequa.*

Reussella aequa Cushman et MacCulloch
(Fig. 105)

The species has been described by Cushman and MacCulloch (Allan Hancock Pacific Expeditions, Vol. 6. No. 5, 1948, p. 251. pl. 31, fig. 7). The description agrees fully with the specimens, found in a sample deriving from Mortensen's Pacific Eenpedition, N.N.E. from Sacal, but for the aperture, which is not, as Cushman describes and figures it, a small rounded opening at the basis of the last-formed chamber, but a slit-like one with the axial side somewhat more widened than the peripheral part, as in all *Reussella*-species. Two forms could be distinguished, the microspheric and the megalospheric forms.

B-form. Slender and elongate test, length up to 0,35 mm, breadth up to 0,9 mm. Throughout triserially arranged chambers; proloculus diameter 10 μ, followed by 7 sets of chambers. Wall of proloculus very finely perforate, those of the later chambers with coarse pores, mainly arranged along the sutures. At each chamber at the angle a blunt, scarcely protruding spine. Chambers increasing rapidly in size in the beginning, but afterwards not increasing in size, so that the sides of the later portion are nearly parallel. Initial part ending in a blunt spine, with other blunt spines at the three angles of it.

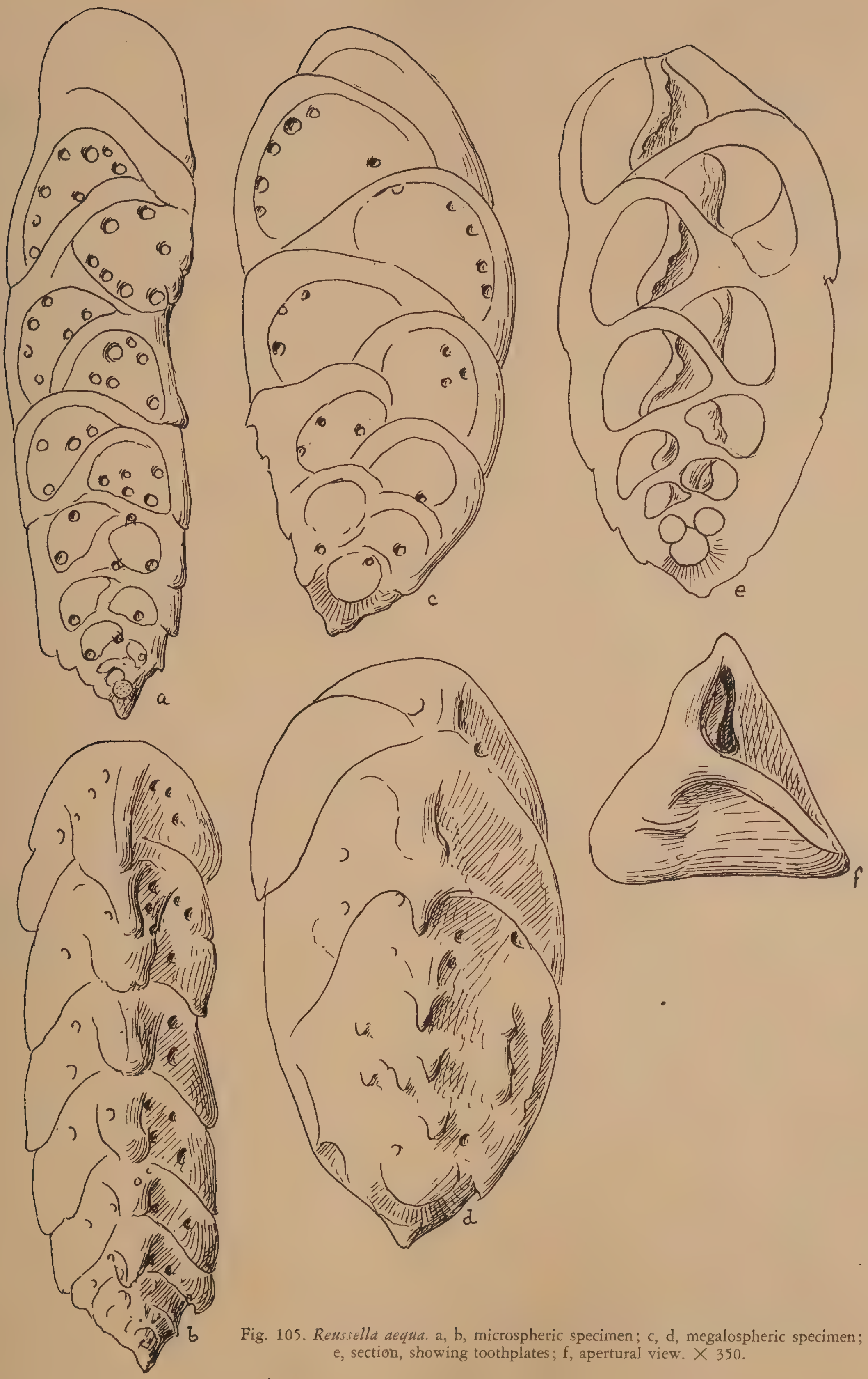


Fig. 105. *Reussella aequa.* a, b, microspheric specimen; c, d, megalospheric specimen; e, section, showing toothplates; f, apertural view. × 350.

A-form. Elongate, but not slender test, length up to 0,50 mm, breadth up to 0,16 mm. Throughout triserially arranged chambers, proloculus diameter about 30 μ, followed by 4-7 sets of chambers. Wall of proloculus very finely perforate, those of the later chambers only with scattered coarse pores, mainly arranged along the distal sutures. The spines at the angles of each chamber now nearly invisible, and the initial end with a blunt spine. Chambers rapidly increasing in size in the beginning, but afterwards the sides of the test nearly parallel.

The toothplate shows not the irregular shape of *Reussella weberi*, and the typical denticulations on the apertural parts of the plate could not be observed. So it may be, that this species does not belong to *Reussella* at all, and that its triangular shape is only a parallelism. The toothplate is of a rather simple type, with a slightly curved back and a poorly developed free folded part. This simple toothplate may indicate, that we have here a primitive species in the genus *Reussella*. This would be so, if e.g. those species from the Cretaceous which have been enlisted in the genus, also show a toothplate of the type, found here.

Reussella weberi nov. spec.

(Figs. 106-109)

In the material gathered by the steamers Van Gogh and Telegraaf, thus from south of Sumatra as well as from the neighbourhood of Flores, *Reussella* occurred, but never abundant. Most specimens were found in a gathering near Flores, 2° S., 99° E., depth 377 fathoms.

The species was moreover found at the stations:

49ª; 8° 23′ S., 119° 4′ E., depth 69 m;
164; 1° 42′ S., 130° 47′ E., depth 32 m;
1° 51′ S., 99° 36′ E., 683 fathoms; abundant
2° 34′ S., 99° 44′ E., 777 fathoms;
5° 21′ N., 107° 14′ E., 43 fathoms (China-Sea).

All three generations were found.

B-form; test with a length up to 0,40 mm, largest breadth 0,20 mm. The large pores only about the sutures of the chambers, spines of test blunt. Proloculus 6-8 μ diameter.

The A_1-form is somewhat more slender than the B-generation, pores somewhat narrower, situated in the same way. Spines somewhat sharper and clearer than in the B-form. Length of shell 0,23 mm, breadth 0,18 mm. Diameter proloculus 10 μ.

In the A_2-form the spines are much more conspicuous and longer. Most individuals of this generation are very small, measuring from 0,15 up to 0,20 mm. Here the pores are narrow, here too situated along the sutures. The walls of the chambers in this generation are thinner than in the other two, and therefore the pores finer also. Only at the initial end the walls are thickened. Diameter of proloculus 17-38 μ.

Transverse sections showed, that the arrangement of the chambers is from the beginning triserial, and that the edges of the shell are formed by these chambers, the septa between the chambers of the same row reaching the outer wall in the middle of a side of the shell.

The aperture always is a more or less narrow slit at the base of the inner margin of the chamber, but this slit becomes more open in the first-formed chambers, and then closely resembles that of *Bulimina*.

This aperture always has one side which is more protruding than the other one, as in *Bulimina,* and this protruding side is formed by the end of a well-developed and somewhat irregular toothplate, which, as in *Bulimina,* e.g. *Bulimina clava,* forms a complicated building. It runs from the former foramen towards the opposite side of the next one, forming a large free flange projecting into the inner part of the chamber, with a retrograde part or tooth at the beginning of it. Then it folds and forms a second foramen closely near the normal one, and very narrow.

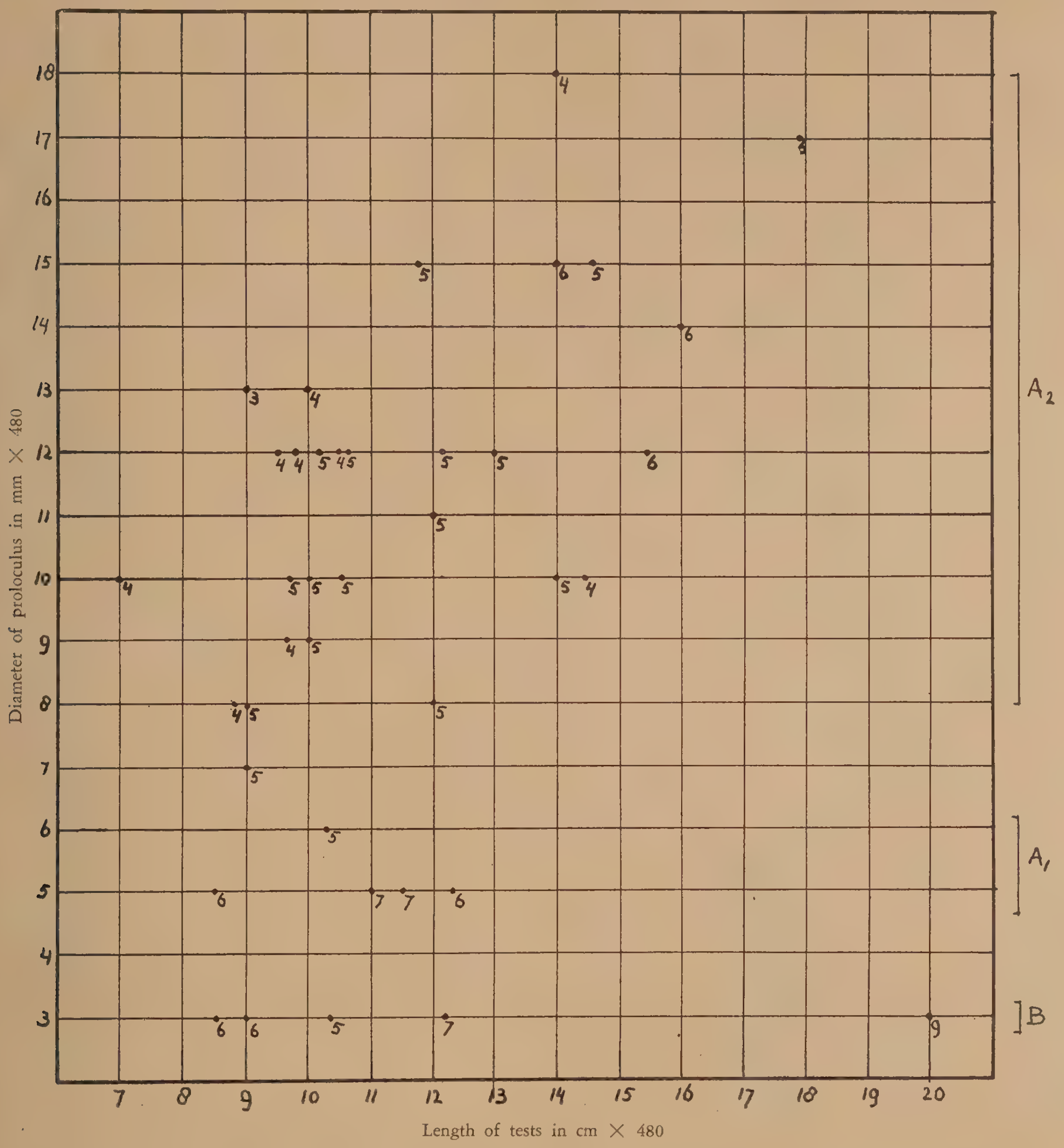


Fig. 106. *Reussella weberi.* Diagram showing relation between length of tests and diameter of proloculus. The figures added give the number of triserial rows of chambers. The diagram clearly shows, that, as in all toothplate-Foraminifera, in the megalospheric forms the length increases with the size of proloculus. In the microspheric generation the number of chamberrows is 5-9; in the A1-generation it ranges from 6-7, in the A2 form 3-6. In this way the three generations can be distinguished from each other.

Al those characteristics lead to the suggestion, that *Reussella* must be very closely allied to real *Bulimina*; the triserial arrangement of the chambers, the conspicuous toothplate, the second

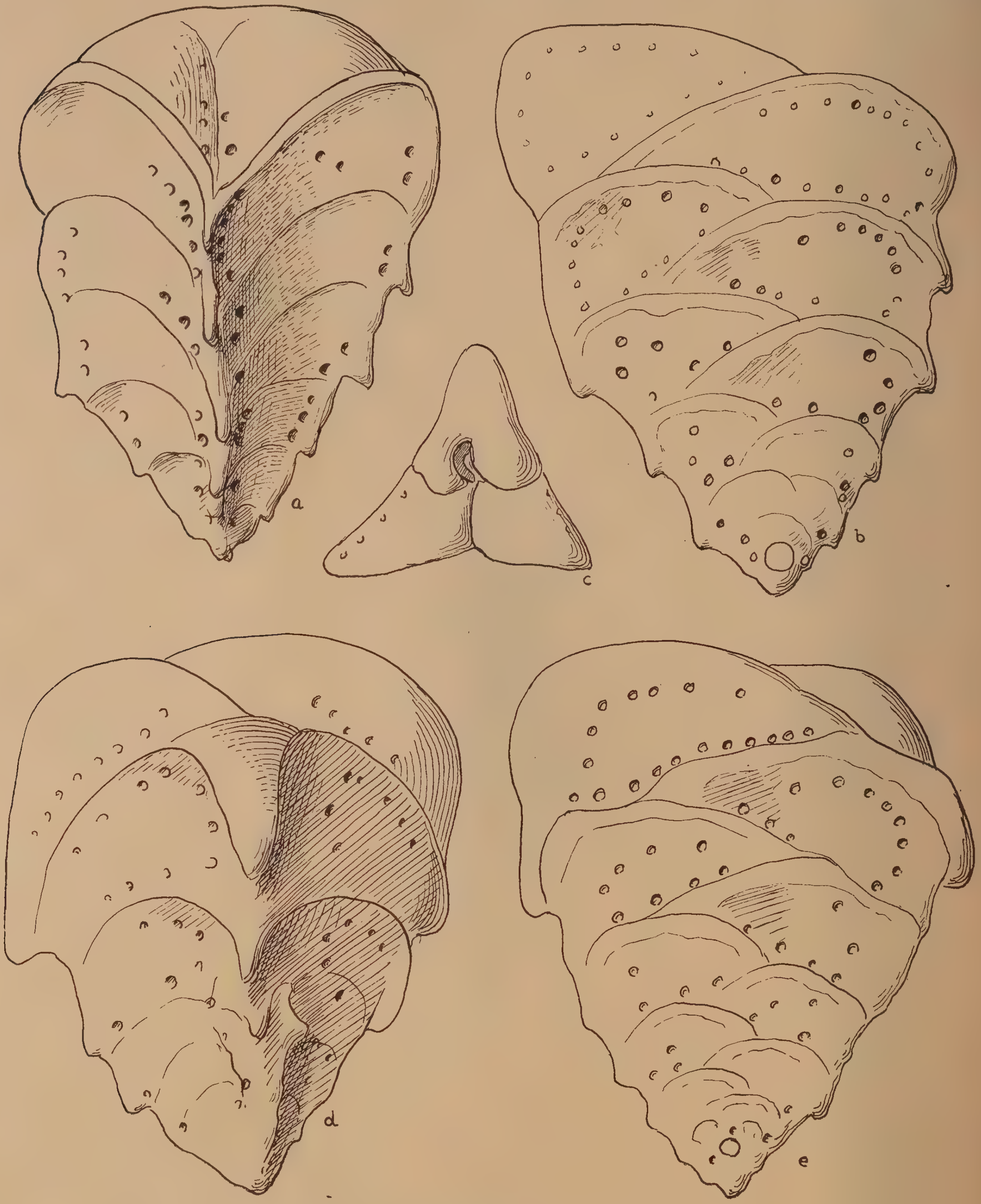


Fig. 107. *Reussella weberi.* a and b, A1-individual; c, apertural face; d and e, microspheric specimen; × 430.

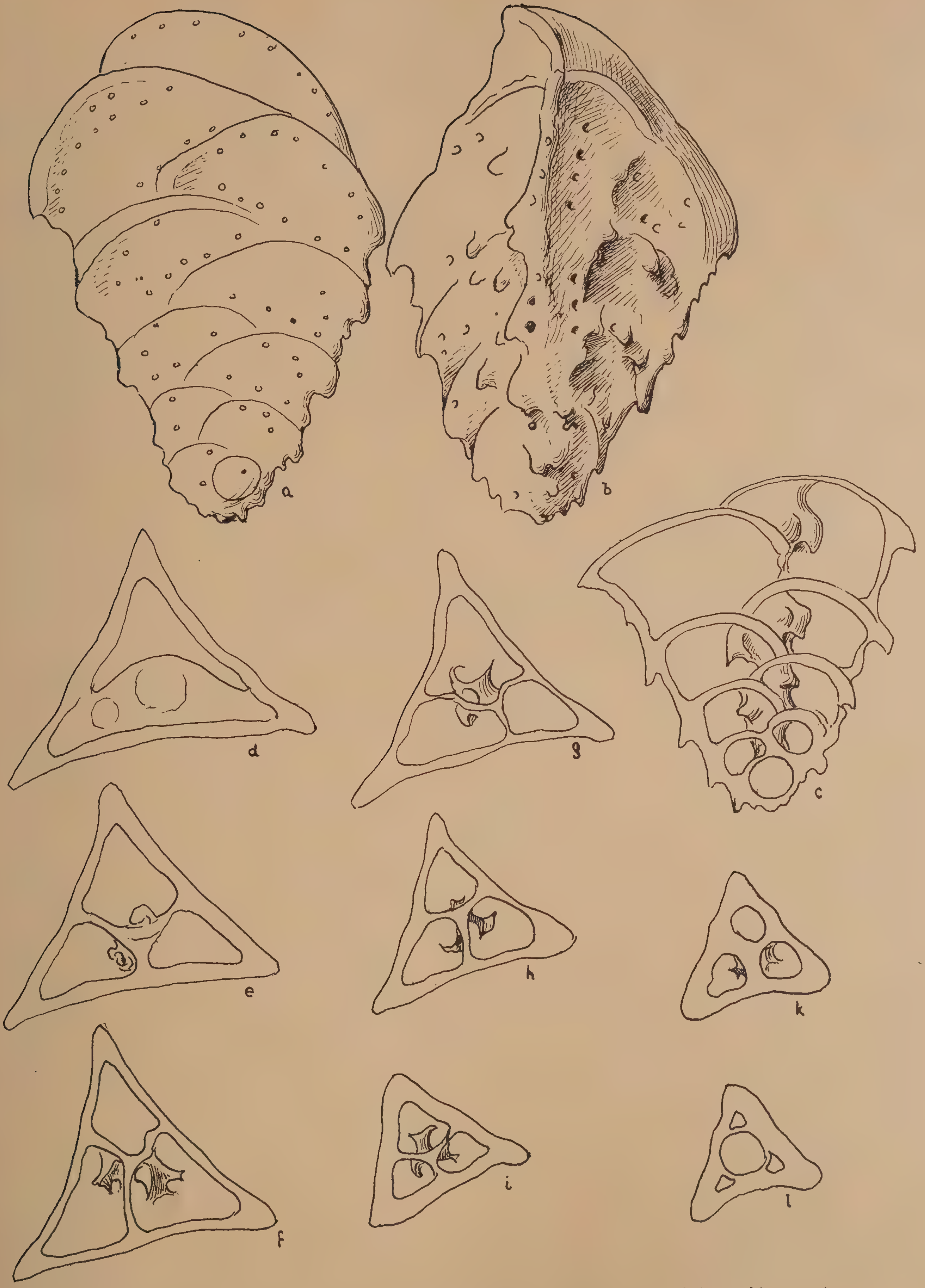


Fig. 108. *Reussella weberi.* a and b, A_2-individual; c, longitudinal section, showing the toothplates; d-l, successive transverse sections; × 420.

foramen, formed by a toothplate which by all means is identical with that of several species of *Bulimina,* the clear wall, etc. The only difference lies in the sutural arrangement of the pores and the largeness of them, and in the edges, formed by the chambers.

What *Trifarina* is among the *Uvigerinidae,* is *Reussella* among the *Buliminidae.* So I am convinced, that there is no real ground to create a separate genus for it, as Galloway did in his manual in 1933. But as the genus *Reussella* now is known as such, I have maintained it here.

The Pacific specimens always were small and not well developed; those from the West Indies, I observed, were much larger and stouter. In some of the Pacific specimens the border of the last-formed toothplates shows a peculiar denticulation, which is a constant characteristic in the specimens from the Caribbean region. These large and stout teeth are mostly developed on the border of the attached part of the plate.

I could study this species from three different regions, viz. the Pacific, the Mediterranean and the West-Indian region. Though from all these regions they are known as *Reussella spinulosa* yet there are constant differences between the specimens. In the Pacific the specimens always are small, the length of outgrown specimens being always about 0,20 mm, whereas the spines at the margin are blunt and the sutures smooth. In the Mediterranean the length has an average of 0,25 mm, the spines are much stouter and larger, in many specimens a large and stout apical spine is found, while the surface at the suture shows blunt spines and irregular bosses. The pores, also situated along the sutures, are somewhat larger too. The toothplate of the Mediterranean specimens shows very few, if at all, denticulations. The West-Indian specimens are always much larger, the length being about 0.50 mm. The surface of these specimens is very smooth and the shell very translucent, while the spines are short and blunt. The Mediterranean form moreover is more slender than the other mentioned specimens. So I am convinced, that the specimens, found in those different regions, do not belong to the same species, but must be regarded as belonging to at least two different species, possibly even to three. The species has been created by Reuss (1850) when dealing with the Foraminifera from the Austrian Tertiary. But Reuss' descriptions and plates do not correspond with our recent knowledge of the group, and therefore it may be, that his species does not all correspond with those, found in recent seas. It may be, that the Mediterranean species shows the closest likeness with the fossil, found by Reuss. It may be also, that the fossil does not at all correspond with the recent species. So I am inclined to give to the three recent species,

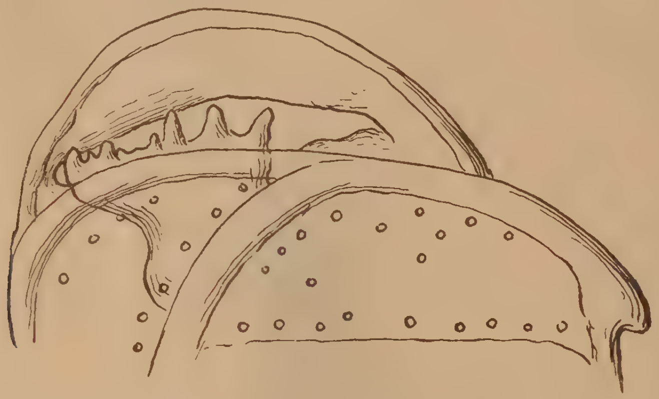


Fig. 109. a, Toothplate of *Reussella weberi,* × 480. showing denticulations on the border of the attached part.

now known, three different names, and to distinguish them from the fossil species, hitherto known as *Reussella spinulosa* (Reuss).

I shall deal with the species, found in the Mediterranean and in the West-Indies in another paper. I will give here to those specimens, found in the different parts of the Pacific region the name of *Reussella weberi,* nov. spec.

Chrysalidinella dimorpha (Brady)
(Figs. 110-112)

Three megalospheric specimens were found at St. 1° 51′ S., 99° 36′ E., depth 683 fathoms, in the Mentawei Basin, south of Sumatra. They showed all characteristics, described by Cushman (U.S. Nat. Mus. Bull. 161, pt. 3, 1942, p. 46). I am citing his description, and add some other points:

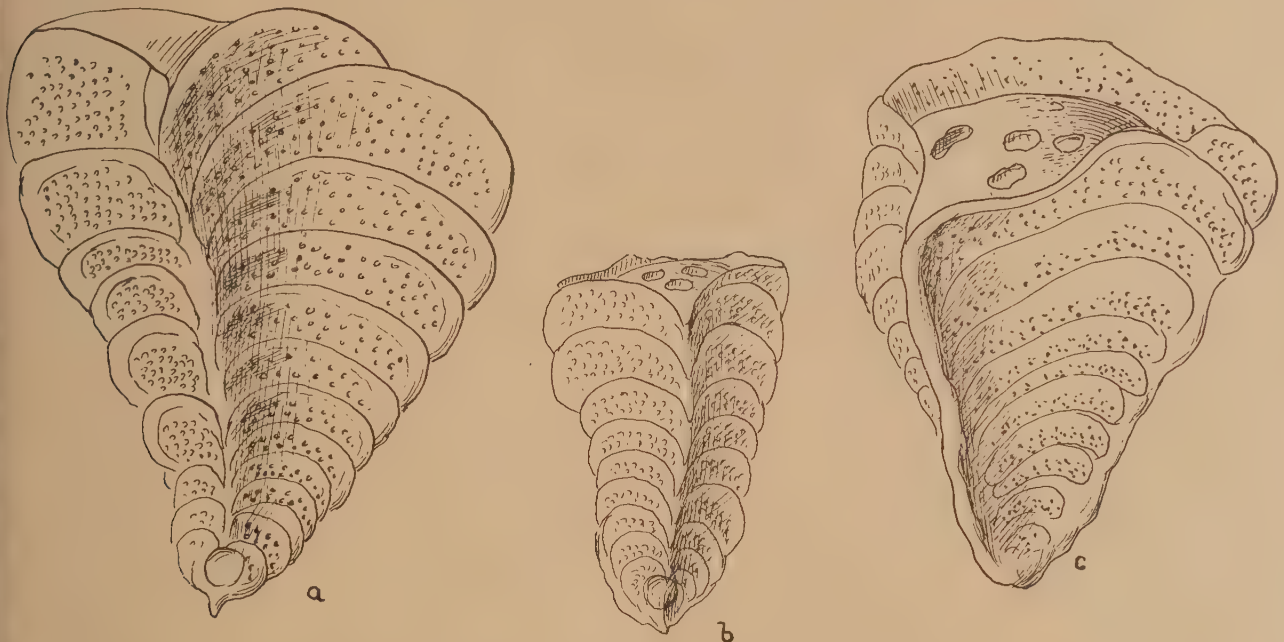


Fig. 110. *Chrysalidinella dimorpha.* Three megalospheric specimens, × 480.

"Test elongate, tapering, triangular in transverse section, the sides nearly equal, flat, or somewhat carinate, angle acute, early portion consisting of chambers triserially, the later portion with chambers in a single series; sutures distinct, slightly limbate, curved, not raised; wall smooth, but distinctly and somewhat coarsely perforate; aperture in the early stages similar to that in *Reussella,* in the adult numerous scattered more or less irregularly over the terminal face of the chamber. Length up to 0,90 mm; breadth 0,40-0,70 mm". The latter measures are altered, as the specimens in this station are much larger than those, mentioned by Cushman. They are all of megalospheric form, probably A$_2$, which in this group often shows the largest tests of the species. Cushman gives 0,50 mm for the length, 0,25-0,35 mm for the breadth.

In my specimens the initial chamber showed a diameter of about 50 μ, and had, contrary to the next chambers, very fine pores, as in most species of the bolivine and allied groups. This characteristic points already to this group. The proloculus was followed by two sets of triserially arranged chambers which show typical, though much reduced toothplates, identical with those, found in *Reussella*. The somewhat coarse pores of these chambers are situated in two or three rows at the initial suture of the chamber, as in *Reussella,* where only one row of coarse pores is found. Then up to 9 uniserial chambers are added, which have a somewhat inflated roof-wall and show no toothplate whatever. This roofwall is pierced by two kinds of pores, small ones, but always larger than the typical pores of the side-walls, and irregular larger ones, to which cannot be given the name of aperture, as they obviously result from absorbing parts of the roof; they show no thickened borders, as is a rule in the Foramina of the group. At the angles of the test a clear hyaline carina is formed; the last-formed chamber always is broken away, apparently caused by the very thin wall, especially the roof-wall.

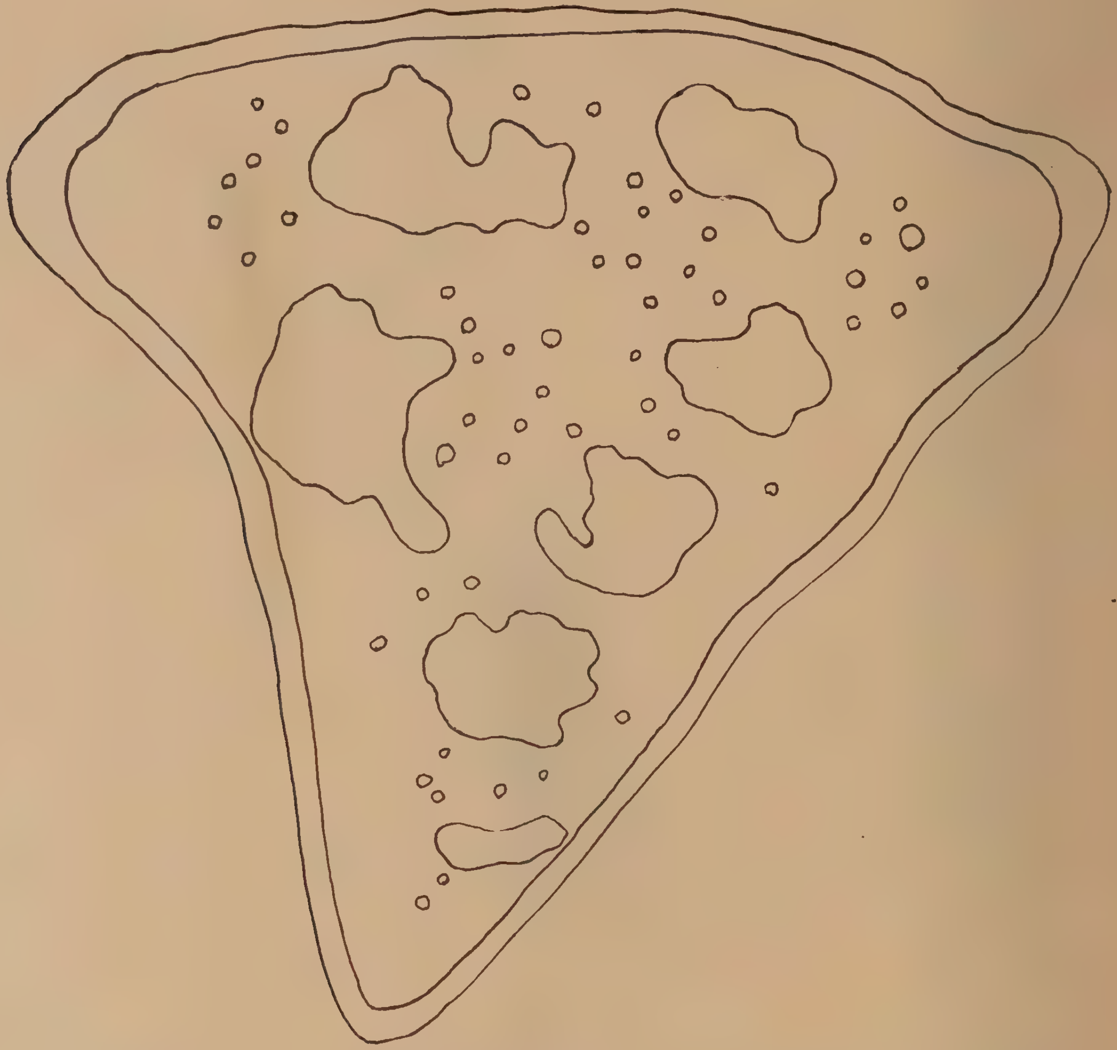


Fig. 111. *Chrysalidinella dimorpha.* View on transverse septum, showing the original pores as well as the absorbed parts, forming the irregular apertures; × 480.

All characteristics point to the only conclusion, that *Chrysalidinella* is an offspring from *Reussella:* the very fine pores of the proloculus, the reduced toothplates of the triserial chambers, the basal arrangement of the pores; and it is very probable, that further observations will lead to the

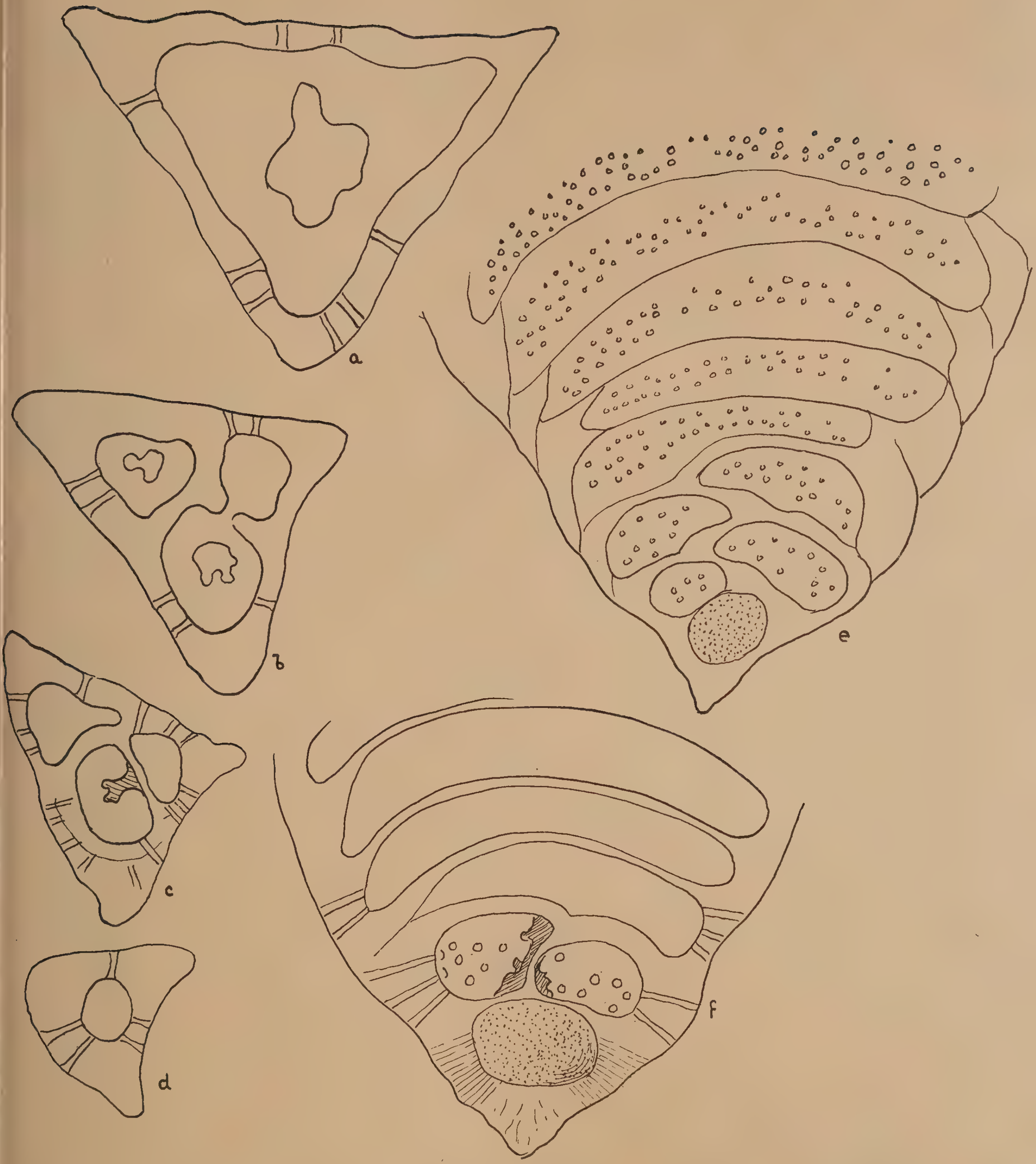


Fig. 112. *Chrysalidinella dimorpha.* a.-e. transverse successive sections; c. with toothplate; e. view on side with pores; f. section, showing the difference between pores of proloculus and next chambers, as well as toothplates in the triserial chambers; × 440.

conclusion, that *Chrysalidinella,* with its few species, must be called *Reussella*; for the forming of uniserial chambers is a character, which occurs too in other genera of the group: *Bolivina* → *Rectobolivina, Bulimina* → *Siphogenerina, Uvigerina* → *Trifarina,* and now *Reussella* → *Chrysalidinella* whereas the same development is found in *Bitubulogenerina elongata.*

In his analysis of the subfamily *Reussellinae,* Cushman (Contr. Cushman Lab., Vol. 21, pt. 2, 1945) gives three recent species of the genus *Chrysalidinella*: *fijiensis* Cushman, *earlandi* Cushman and *dimorpha* Brady. In 1948 (Allan Hancock Pac. Exp., Vol. 6, pt. 5, p. 256, pl. 32, figs. 1-7) Cushman and McCulloch erected a fourth recent species, *C. spectabilis.* In this species the later chambers tend to become compressed and flat. But no details are given about the pores, so that we cannot even be certain, whether the species belongs to *Chrysalidinella* or not.

Genus **Bitubulogenerina**

The characters of this genus may be read in Cushman, 1937, with the addition, that the pores are always very distinct, often sutural, the walls always very hyaline, the chambers always with angular basal sutures, and mostly longitudinal costae, ending in spines, whereas the toothplate always consists of a flaring attached part, often provided with typical teeth on its free border.

This toothplate, with its denticulations and its flaring attached part, closely resembles that of *Reussella.* The arrangement of the pores and the hyaline walls, together with the triserial arrangement of the initial part, point likewise to that genus. It is therefore, that I place this genus in the vicinity of *Reussella,* may be, that it developed from it.

The genus was believed to be extinguished in the Tertiary, and seemed to occur only in the Miocene. But in the Pacific I found four species, belonging undoubtedly to the genus *Bitubulogenerina,* while in the West-Indian regions I detected a fifth one. So the genus is also a recent one, but the real inner structure of several of these recent species has been neglected, so that several species have been looked at as *Bolivina.*

The development of triserial arranged first stage in *Bitubulogenerina* may be a reminiscence of a triserial test, and then *Bitubulogenerina* might have developed of a triserial ancestor, such as *Bulimina.* But it is probable, that *Bitubulogenerina* has got its triserial first chambers as a new development, and then it would have been developed from *Bolivina.* The toothplate of *Bitubulogenerina,* with its flaring attached part, points more in the direction of *Reussella* than of *Bulimina.* But, as this problem cannot be solved yet, I placed it, according to its triserial arrangement, in the neighbourhood of *Reussella.*

Bitubulogenerina vertebralis (Cushman)
(Fig. 113)

This species has been described by Cushman as *Bolivina vertebralis* (Carn. Inst. Publ. 342, 1924, p. 20, pl. 3, figs. 3, 4), later as *Loxostoma vertebrale* (U.S. Nat. Mus., Bull. 161, pt. 3, 1942, p. 37-38). It was found at Tonga-Islands.

In several deep gatherings south of Sumatra, e.g. at St. 2° 34′ S., 99° 44′ E., depth 777 fathoms, the species was found, always rarely. The hyaline test begins triserially, and in the megalo-

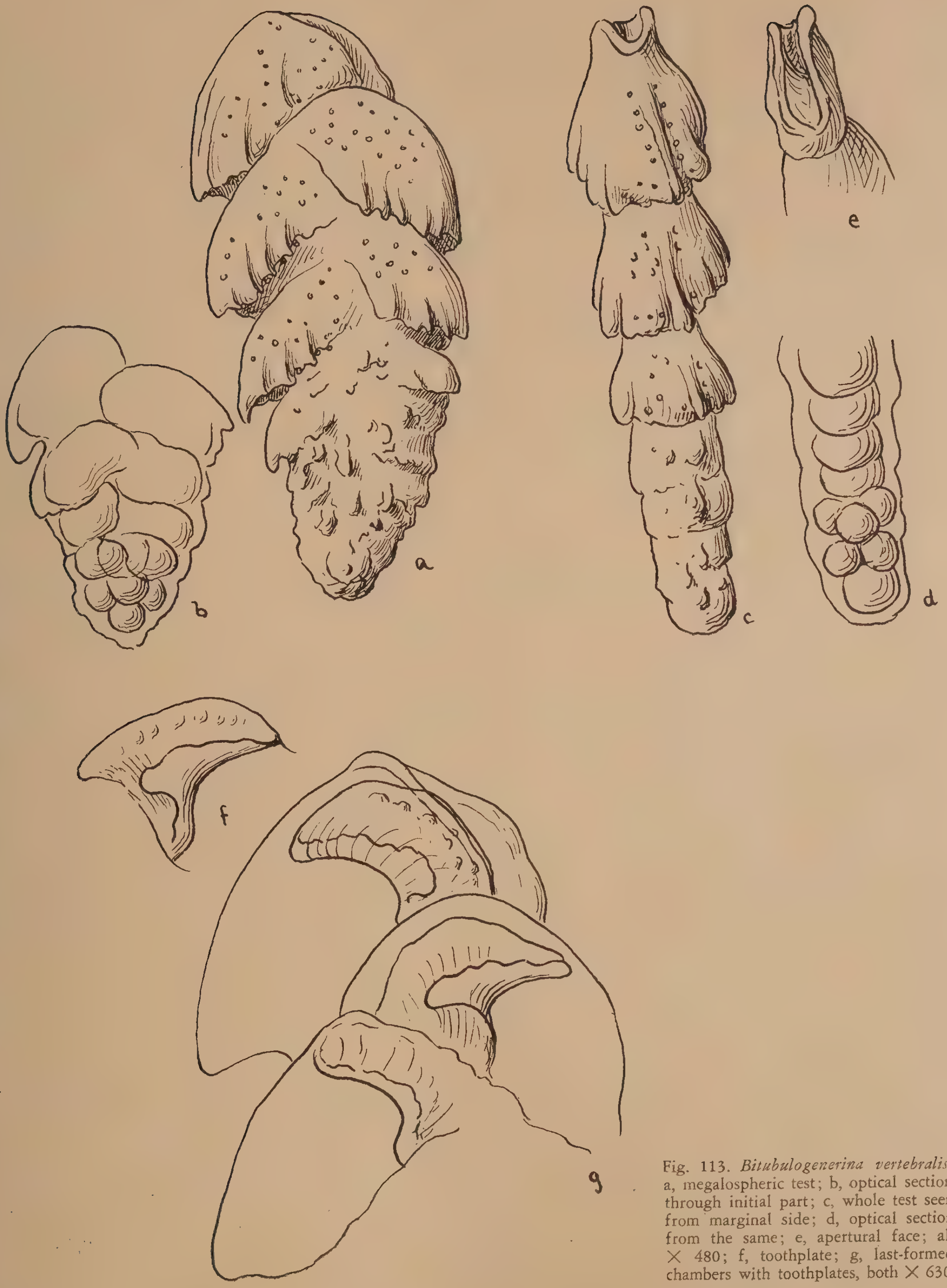


Fig. 113. *Bitubulogenerina vertebralis.* a, megalospheric test; b, optical section through initial part; c, whole test seen from marginal side; d, optical section from the same; e, apertural face; all × 480; f, toothplate; g, last-formed chambers with toothplates, both × 630.

spheric form, the only form found, the proloculus measures 16 μ, and is followed by two sets of triserially arranged chambers. Then 5 sets of biserial chambers are added. The chambers show the typical scattered fine but distinct pores of *Bitubulogenerina,* with longitudinal costae on the chamberwalls, ending at the basal sutures in distinct spines, directed toward the initial part. Pores open between those short spines. The chambers are inflated, with a protruding and angular suture at the base of each chamber, as in most species of this genus. The aperture is more or less terminal, a long slit with distinct lips. It shows a very typical toothplate, differing from that of the species found in the West-Indies. As in the West-indian species, *B. pulchella,* the toothplate shows the shape of that of *Reussella,* with its fan-shaped attached part. But the free part herein is only a narrow part, and the borders of the toothplate show not the spines, characteristic for *B. pulchella.*

Description of the species:

Test in the early part triserial, later biserial. Test elongate, slender, slightly tapering toward the apertural end. Chambers inflated, with carinate basal suture. Margin carinate. Walls of chambers with irregular longitudinal costae ending into small sutural spines. Sutures depressed. Total test compressed. Walls hyaline with scattered, distinct, though small pores. Aperture elongate, more or less terminal, with thickened borders and a flaring toothplate with narrow free part.

Length of megalospheric test 0,25 mm, breadth 0,10 mm, thickth 0,05 mm.

Bitubulogenerina lobata (Brady)
(Fig. 114)

This species was found in some abundance at St. 2° 26′ S., 100° 0′ E., depth 222 fathoms. It has nothing whatever to do with *Bigererina fimbriata* Millet, which may be stated directly at closer examination. It has been described by Brady as *Bolivina lobata,* and by Cushman (Spec. Publ. Lab. For. Res., No. 9, 1937, p. 188, Pl. 22, figs. 2-4) as *Loxostoma lobatum* (Brady).

The tests are small, tapering at the beginning, later the total breadth does not increase. Chambers inflated, with projecting angle at the margin, projecting backward. Sutures not very distinct, but the apertural suture of each chamber thickened (the remainder of the thickened apertural lip). Wall hyaline, thin at the apertural end, but thickened at the initial part. Two kinds of pores; one kind is covering the whole surface of the chamber, and consists of very fine pores which are, however, somewhat scattered over the surface; the other kind consists of much coarser pores, and is found along the margin of each chamber, especially at the protruding angle. Between those larger pores some short spines may be developed.

The first set of chambers consists of a very small proloculus in all specimens (diameter 6 μ) followed by three chambers in a whorl, and then biserial chambers are added. Thus the triserial arrangement of the first-formed chambers, characteristic for the genus *Bitubulogenerina,* is also found here, together with the angled chambers. The aperture is a yawning opening, more or less terminal, with a distinct lip around its borders and a toothplate, the attached part of it having fine pustules on its inner side, whereas the free part is reduced, the folded part being only left.

All these characteristics lead to the suggestion, that the species does not at all belong to *Loxostoma,* which shows always quite a different toothplate, but that it is closely allied to several wellknown species of *Bitubulogenerina.*

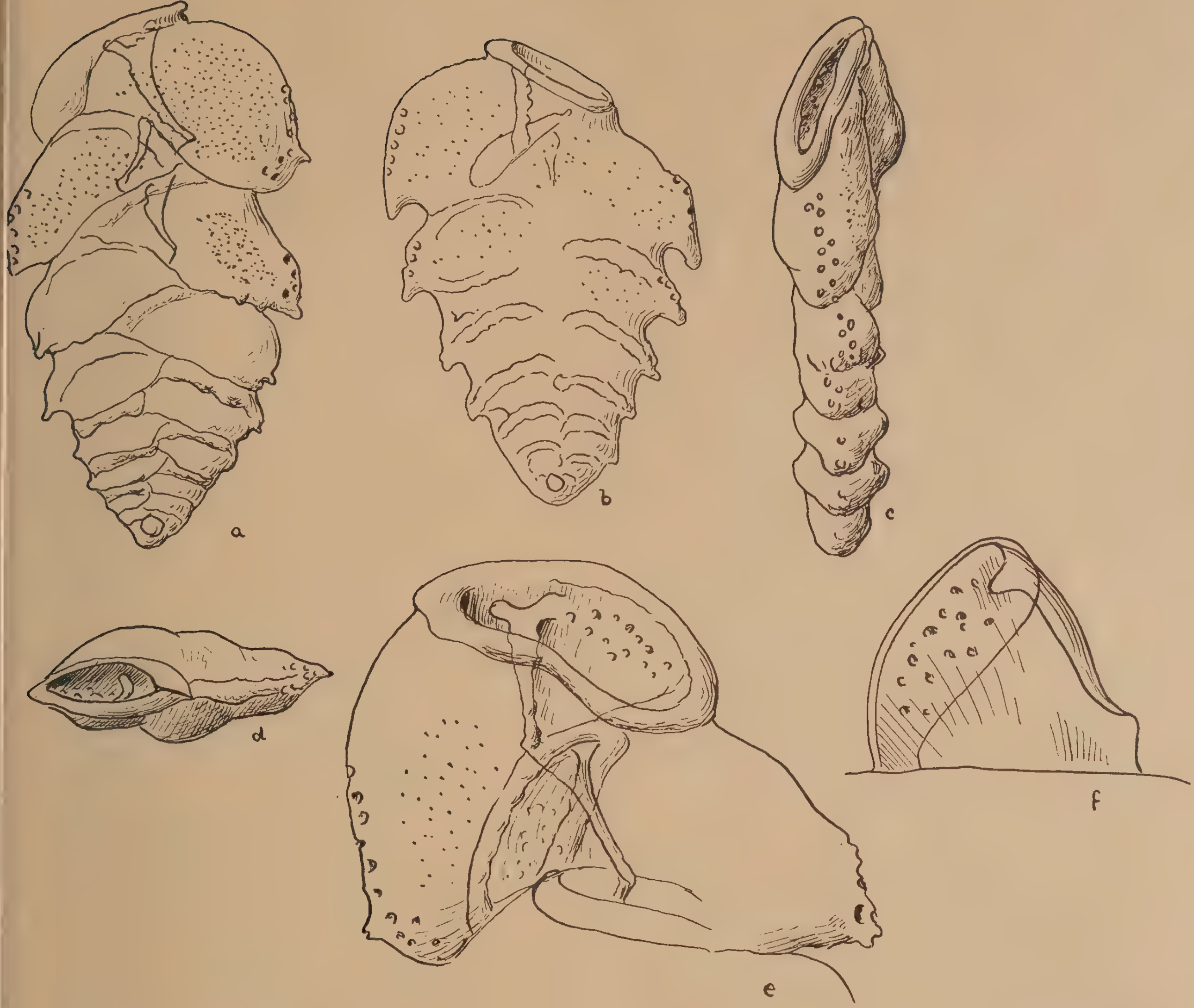


Fig. 114. *Bitubulogenerina lobata.* a and b, whole tests; c, sideview; d, apertural face; × 440; e, end of test, with the toothplates of two chambers, showing the tubercules at the inner side of the attached part; × 580; f, toothplate; × 580.

Bitubulogenerina convallaria (Millet)
(Fig. 115)

This species, formerly described as *Bolivina convallaria* Millet, later (Cushman 1937, p. 191) as *Loxostoma convallarium,* is without doubt a species, belonging to the genus *Bitubulogenerina* (U.S. Nat. Mus., Bull. 161, pt. 3, 1942, p. 37, Pl. 10, fig. 6). There are some typical characters, which are found in all specimens, gathered at different localities south of Sumatra (e.g. St. 2° 26′ S., 100° 0′ E. depth 222 fathoms, 2° 17′ S., 99° 27′ E. depth 377 fathoms). When seen in transmitted light, the test is greyish and opaque, due to very fine agglutination(?) on the walls, which is of wholly calcareous material. So pores cannot be observed. Only the spinous elongations of the margin of each chamber are totally hyaline. The first set of chambers consists of a relatively small proloculus, followed by two sets of triserial chambers. Then the biserial chambers are added, each with a distinct spine at the periphery of the test. The sutures in the first part are diffuse, but the later ones are distinct, due to a more or less crenulate ridge along the initial suture of each chamber. The later chambers are very much inflated and tend to become uniserial. The aperture is a more or less

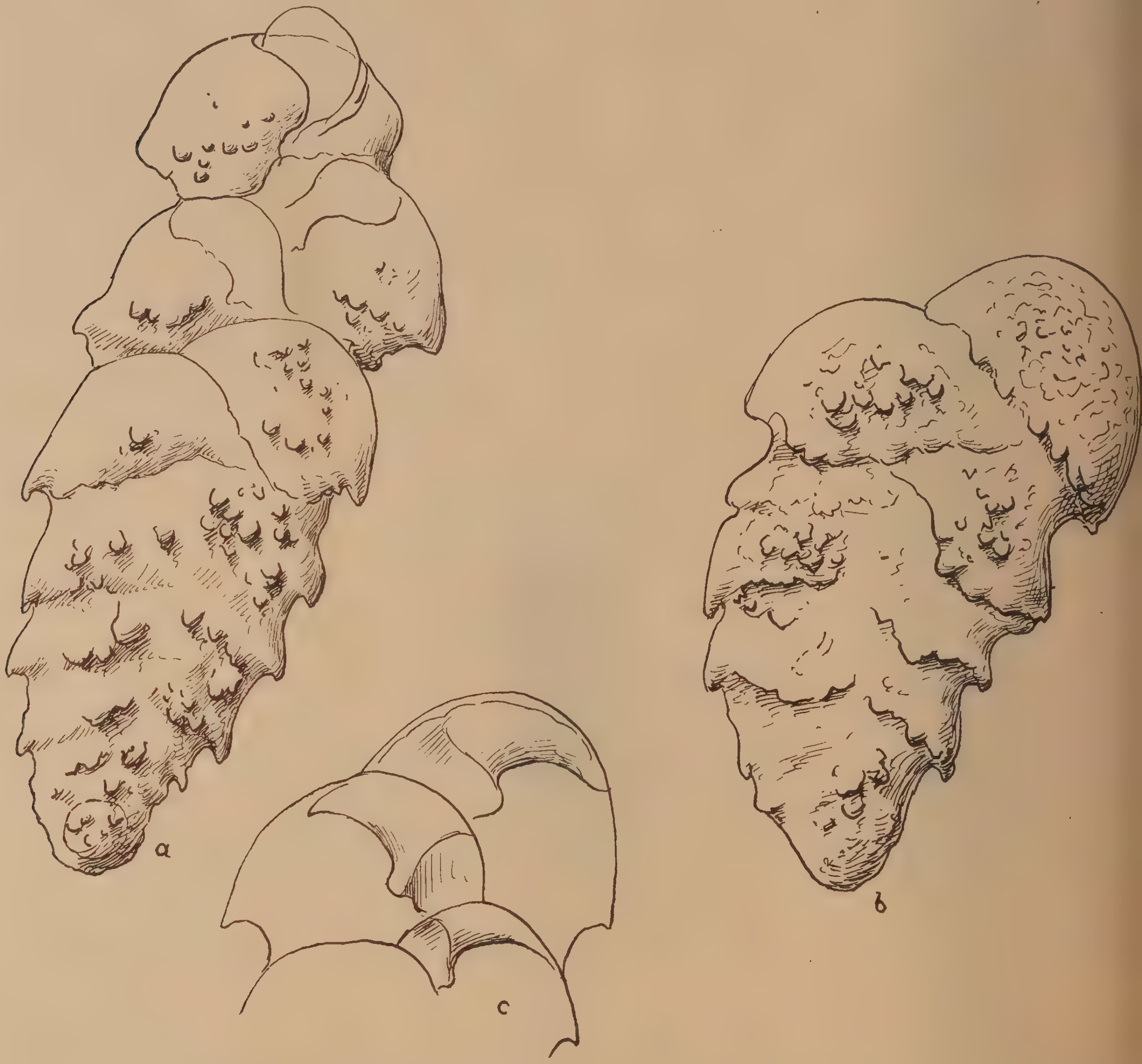


Fig. 115. *Bitubulogenerina convallaria.* a and b, two specimens; c, apertural end with toothplates. × 630.

terminal opening, provided with a large toothplate, typical for the genus. The attached part of it is somewhat protruding from the mouth. Length of tests up to 0,30 mm, breadth 0,10 mm.

The species seems to be very rare. Millet and Heron-Allen and Earland (Kerimba) have mentioned it, Millet from the Malay Archipelago. Cushman describes it from Fiji-Islands, in shallow water.

Bitubulogenerina elongata (Millet)
(Fig. 116)

This species has been found only in a single specimen N.E. from Sacal, Philippines, depth 30 fathoms. The specimen was well-preserved, and I will describe it here (Mortensen's Pacific Expedition). Later a specimen was found at Merak anchorage.

Test slender and elongate, compressed, especially in the uniserial part which forms most of the test. The proloculus measures about 20 μ, and was followed by a single set of somewhat triserial arrangement, then by 5 chambers of biserial arrangement, and 8 uniserial chambers which, however, all show the distinct bolivine alternating position of the aperture. All chambers show at their proximal sutures short spines, directed toward the initial end. The biserially arranged chambers clearly show typical blunt longitudinal costae, as are found in several other species of the genus (e.g. *B. pacifica* and *B. pulchella*). In the uniserial chambers these costae are not visible. The aperture is a long slit, beginning at the ventral suture, running over the apertural face of the chamber, and ending at the dorsal side of the chamber in a prolongation overlapping the former chamber, but here closed by a porous wall. The raised borders of the aperture are running over this prolongation up to the end of it. So the aperture is not at all a terminal one, as has been suggested, but a typical sutural opening, very much extended over the last-formed chamber up to its dorsal side.

In the biserial chambers the toothplate is much like that of *Bitubulogenerina pulchella,* but in the uniserial chambers it shows the same typical difference, which is also found in species of the genus *Rectobolivina* and in other groups with uniserial chambers (*Loxostoma*): it has loosened its attached part, so that both parts are free. But unlike the free toothplates of *Loxostoma* and of *Rectobolivina,* it is not a straight plate, but it maintains its very curved folded back, thus once more showing the difference with *Loxostoma* and *Rectobolivina.*

The pores are protopores, and show quite the same size and situation as is found in *Bitubulogenerina pulchella.* The walls are very hyaline, and very thin.

Length 0,60 mm, breadth 0,10 mm, thickness 0,7 mm.

In all characteristics this species shows that it is nothing but a *Bitubulogenerina,* in which the later chambers have become uniserial. As I am certain, that the genera *Loxostoma* and *Rectobolivina* are no real genera, as in many species of the toothplate-Foraminifera the tendency to form uniserial sets of chambers is a fact (*Bolivina, Uvigerina, Valvulinidae*), I think it to be very inadequate to create here a new genus, and so I will maintain the generic name of *Bitubulogenerina,* so that the species is not at all a *Bifarina,* but a *Bitubulogenerina elongata.* It has been described by Millet as *Bifarina elongata* (Journ. Roy. Micr. Soc., 1900, p. 539, pl. 4, fig. 1, 2).

Family *Uvigerinidae*
(Figs. 117, 118)

The *Uvigerinidae* are toothplate-Foraminifera, showing in earlier forms from the Cretaceous an aperture which is provided with pores on its neck, and lacks the typical phyaline lip, surrounding the aperture. When the tertiary *Uvigerinae* develop, the family is already divided into two groups, one having the features of *Angulogerina,* with triangular transverse section. Those *Angulogerinae* from the Tertiary show the primitive characters: pores on the neck, no true phyaline lip. But the

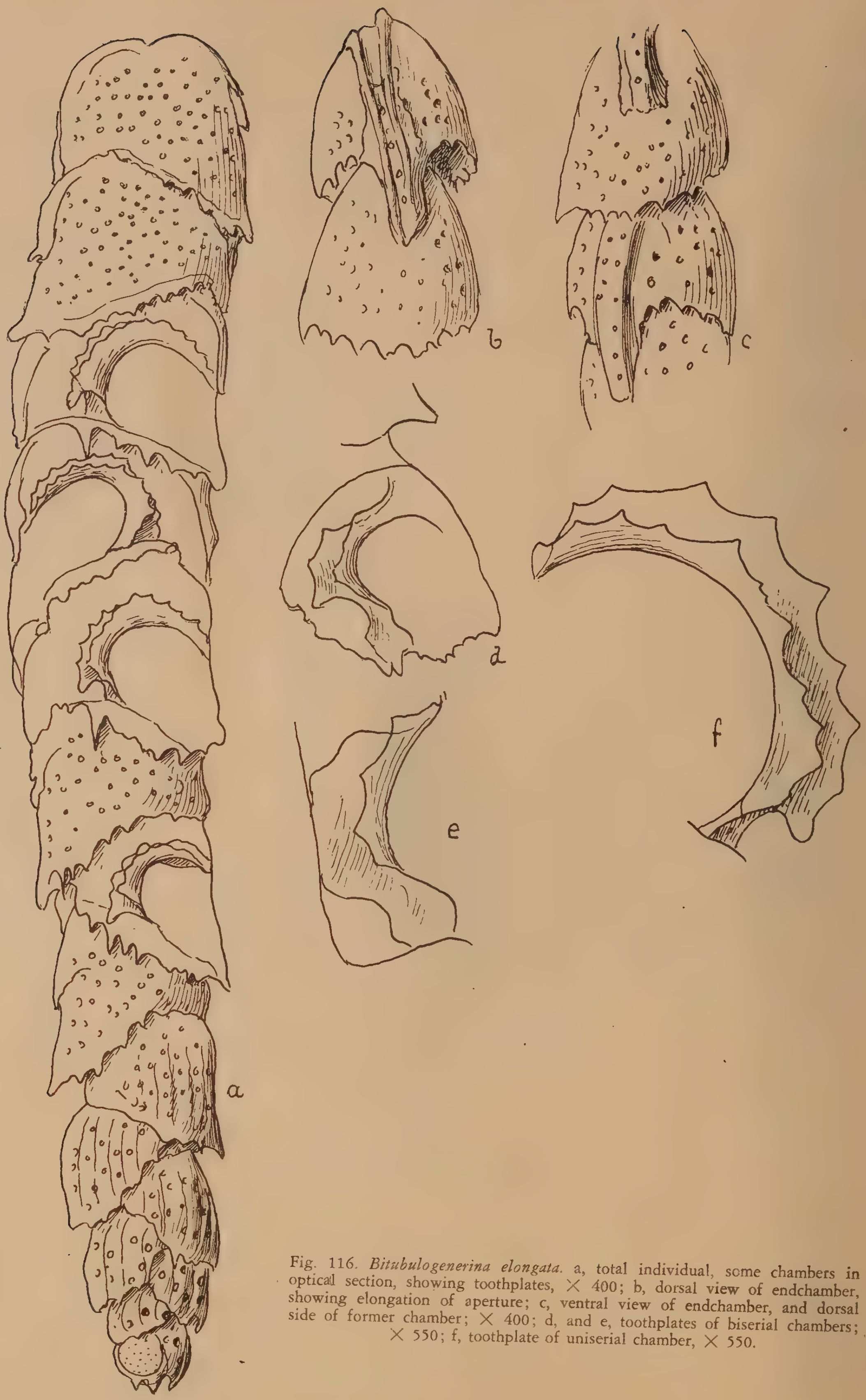
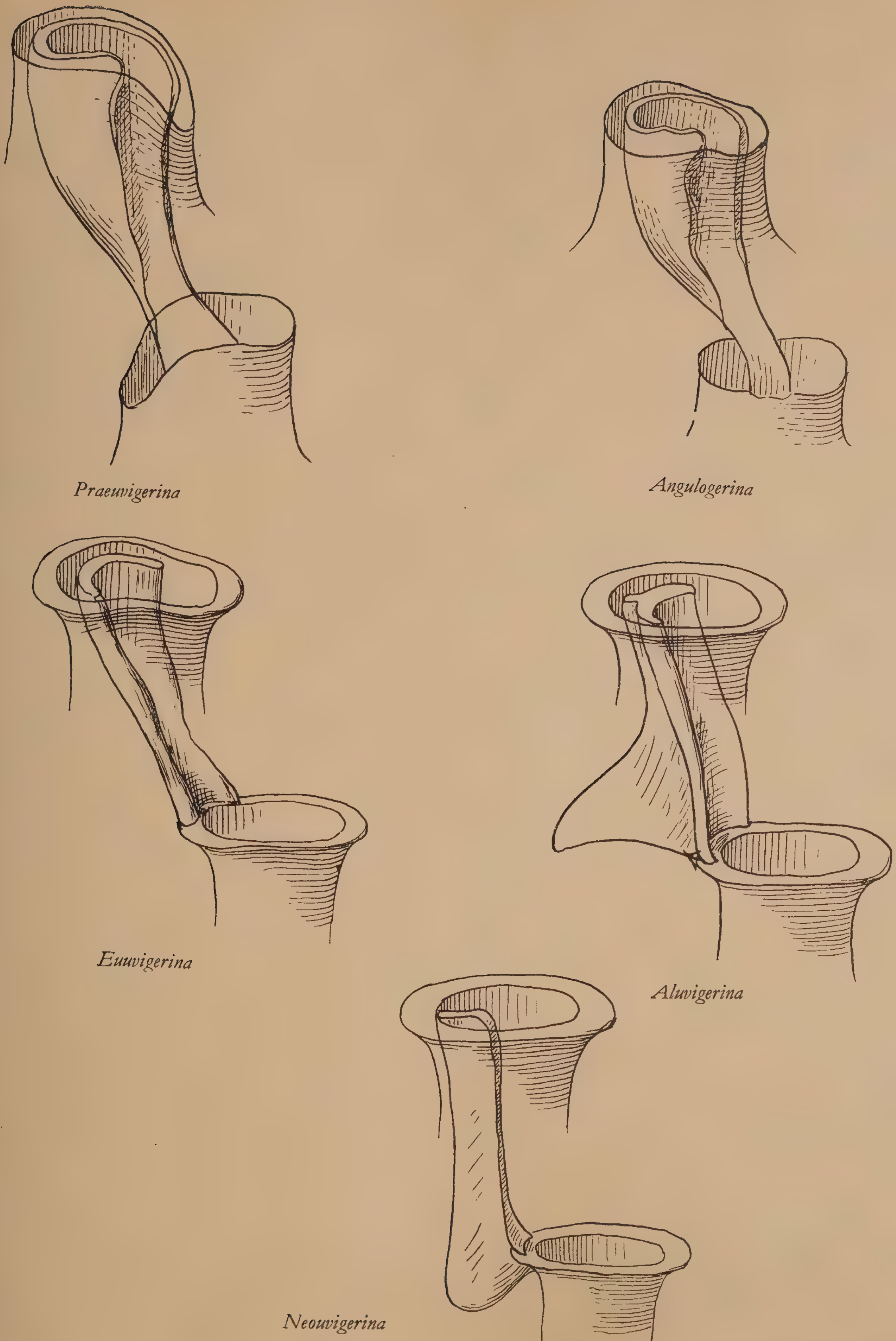


Fig. 116. *Bitubulogenerina elongata.* a, total individual, some chambers in optical section, showing toothplates, × 400; b, dorsal view of endchamber, showing elongation of aperture; c, ventral view of endchamber, and dorsal side of former chamber; × 400; d, and e, toothplates of biserial chambers; × 550; f, toothplate of uniserial chamber, × 550.



Praeuvigerina

Angulogerina

Euuvigerina

Aluvigerina

Neouvigerina

Fig. 117. *Uvigerinidae.* Idealised toothplate-drawings, showing the development from those in cretaceous *Praeuvigerina* into those of recent *Neouvigerina.*

Uvigerinae of the Tertiary show the more recent characters already, neck without pores, phyaline lip.

In the cretaceous species, I observed, the toothplate is of the type of *Virgulina,* with an attached side, and a free one, the latter folded to form a real tooth. In the Oligocene *A. oligocaenica,* the toothplate shows those primitive characters. The same can be said from *Angulogerina ornata* and of *Angulogerina tricarinata.* The latter species shows most reduced toothplates, the free part being only indicated. This genus in adult species is uniserially arranged in its last-formed chambers, and modern authors have created a new genus for it, viz. *Trifarina.* I do not believe that this single species with uniserial later chambers is important enough to create for it a genus, and in any case it should be a sub-genus as well. In *Angulogerina occidentalis* the toothplate likewise has reduced its folded free part.

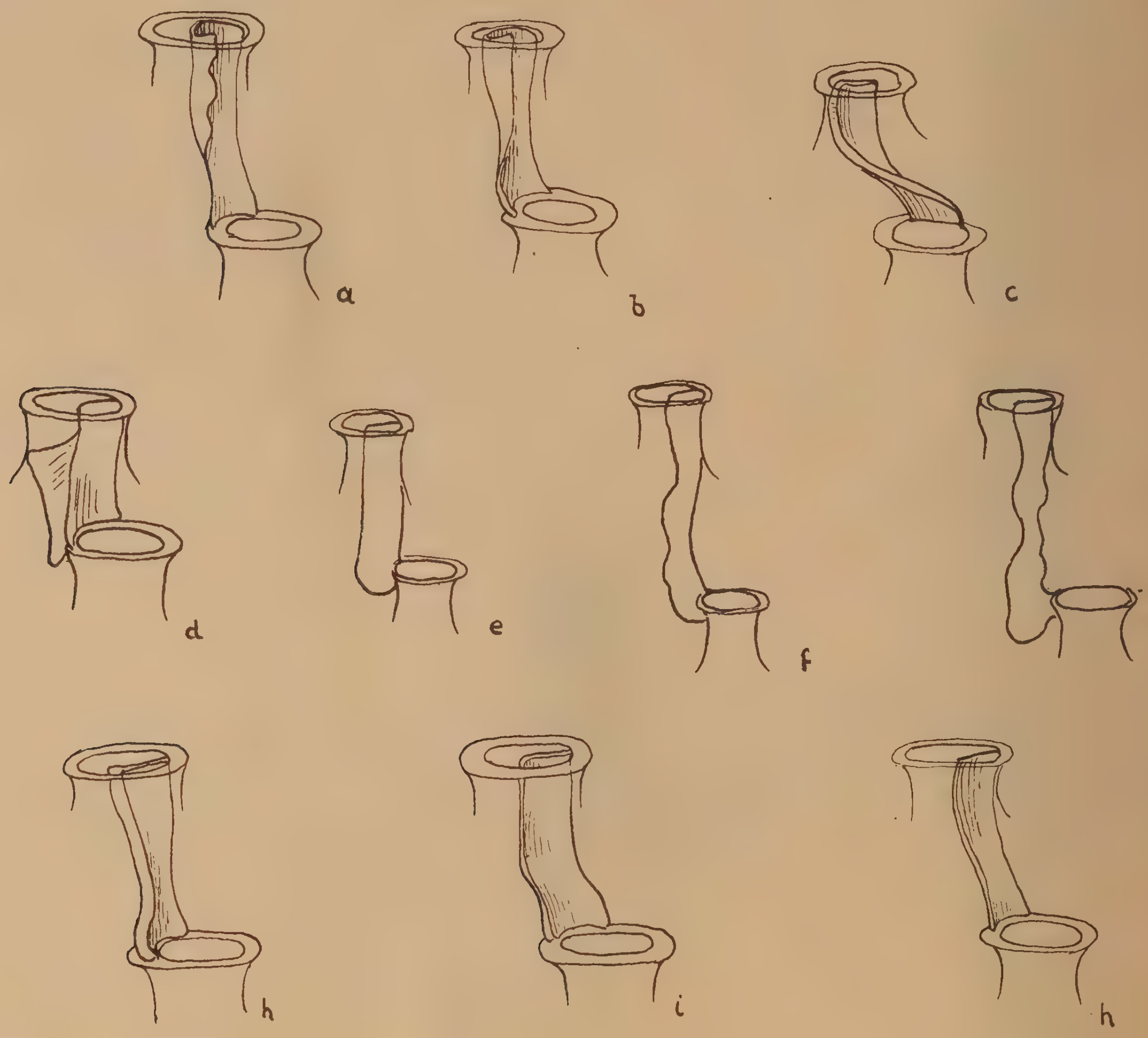


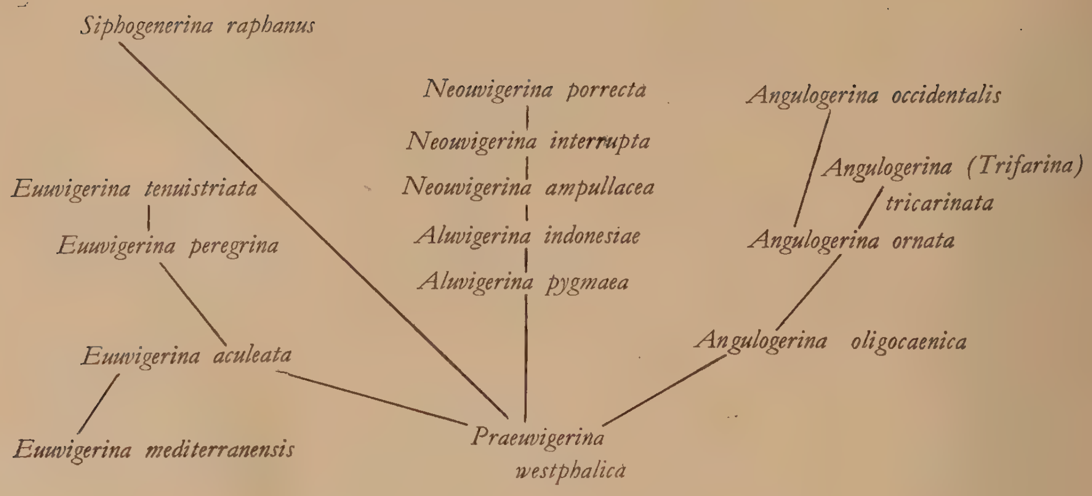
Fig. 118. *Uvigerinidae,* toothplates. First row. a, *Angulogerina oligocaenica*; b, *Ang. ornata*; c, *Ang. tricarinata* (*Trifarina*).
Second row: d, *Aluvigerina peregrina;* e, *Neouvigerina ampullacea*; f, *Neouv. interrupta*; g, *Neouv. porrecta.*
Third row. h, *Euuvigerina aculeata*; i. *Euuv. peregrina*; h, *Euuv. tenuistriata.*

On the other hand a group of *Uvigerinae* shows a toothplate, reduced into a simple plate, with its total breadth beginning at the border of the former aperture, and running into the next one, attaching itself with one of its sides to the inner side of the neck. In *U. aculeata* the plate shows at one side a remainder of the folded free part, in *U. peregrina* and in *U. tenuistriata* the plate is very simple. Especially in *U. tenuistriata* the plate is thin, in *U. peregrina* and *U. aculeata* it is thicker.

Höglund (1947) described in *U. pygmaea* a plate, which shows an adherent wing, stretching itself backward from the back of the plate. I could trace such wings in real *U. pygmaea,* while in *Uvigerina indonesiae* this wing shows already the form of the toothplate of *Uv. ampullacea,* though the toothplate itself is present. This wing may have been the first beginning of quite a different shape of toothplate, found in *U. ampullacea, U. interrupta* and *U. porrecta.* In these three species which are furthermore distinguished by their forming of uniserial chambers at their adult ends the plate begins with its narrow side attached to the outer border of the phyaline lip of the former aperture; then it runs straight upward unto the neck of the next aperture, where it attaches itself to the inner side of the neck. In this way this plate shows a similar situation, as is found with the wing of the species, described by Höglund, so that we can be sure, that *U. pygmaea* and *U. indonesiae* are links between *Uvigerinae* with a simple real toothplate, attached with its broad base along the lip of the former aperture, and those plates, which are attached only with their sharp side. These averted toothplates are nothing but the wings of the toothplates, indicated by Höglund, and their real toothplates are reduced. It is a remarkable fact, that just these species show the tendency to have uniserially arranged chambers. I believe, that this is reason enough to create new genera. Forms such as *oligocaenica, tricarinata,* and *ornata* may be called *Angulogerina* (toothplate with more or less developed free folded part), whereas *tricarinata* may or may not have a special sub-generic name (*Trifarina*); forms with simple real toothplate, such as *aculeata, peregrina, tenuistriata,* may be called *Euuvigerina*; forms with a dorsal wing at the toothplate (*U. pygmaea*) may be called *Aluvigerina*; forms with the wing as only remaining part of the toothplate may be called *Neouvigerina.* These forms must not be confused with the genus *Eouvigerina,* which is not an *Uvigerina* at all, lacking any trace of a toothplate. For those *Uvigerinidae* which, in the Cretaceous, show no real neck with phyaline lip, I propose the generic name of *Praeuvigerina.*

A careful new study of the genus *Siphogenerina* has to be carried on, to find out, whether those forms in this genus which begin with a triserial part, are related with *Uvigerina* or not. As I showed already, many species hitherto believed to belong to this genus, are in reality species of the genus *Rectobolivina.* Yet it may be, that those forms which show a well-developed neck and phyaline lip, may be in some cases *Uvigerinidae.* Only study of the inner structure will reveal this. I propose to hold up this generic name *Siphogenerina* for those forms with triserially arranged first part, especially in the microspheric generation.

The relations of these groups within the family of the *Uvigerinidae* will be shown in next scheme.


Siphogenerina raphanus
Neouvigerina porrecta
Neouvigerina interrupta
Neouvigerina ampullacea
Aluvigerina indonesiae
Aluvigerina pygmaea
Angulogerina occidentalis
Angulogerina (Trifarina) tricarinata
Angulogerina ornata
Angulogerina oligocaenica
Euuvigerina tenuistriata
Euuvigerina peregrina
Euuvigerina aculeata
Euuvigerina mediterranensis
Praeuvigerina westphalica

Geographical distribution in the Indonesian Archipelago. Nearly all *Uvigerinidae* are found mostly in the western part of the Archipelago. The only records in the eastern part are of *Euuvigerina, Neouvigerina ampullacea,* and of *Angulogerina occidentalis* and *Aluvigerina indonesiae.* While *Angulogerina occidentalis* shows a toothplate which may be the most modern form of the group, *Aluvigerina indonesiae* shows several primitive characteristics. Of *Angulogerina tricarinata* some specimens of a very small and weak form occurred in the eastern part; it may be a different species, as to its smallness.

The aberrant *Siphogenerina raphanus* was found only in some gatherings of the eastern part of the Archipelago, but only in few specimens. This is very peculiar, and shows, that the family of the *Uvigerinidae* has obviously developed in western seas, and then migrated into the eastern Pacific, while the Australian continental area is not a hearth of development for the family. Yet *Uvigerina pygmaea* is mentioned from Australian Pliocene beds (Parr).

Cushman (Bull. 100 U.S. Nat. Mus., 1921) records *Uvigerina* from the following stations

U. pygmaea from 4° N. to 5° S. and from 118°-120° E., Strait of Macassar;
U. tenuistriata from 4° 10′ N., 118° 39′ E. and 2° 54′ S., 118° 47′ E., Celebes-Sea and Macassar-strait;
U. Schwageri and *U. aculeata* 4° N.-4° S. and 118-127° E., around Celebes;
U. ampullacea, 5° N.-5° S. and 120-122° E., Eastern from Celebes;
U. interrupta 0° N.-4° S. and 118°-127°E., around Celebes.

Genus **Praeuvigerina**

(Fig. 119)

This genus, with as a type-species *Praeuvigerina westphalica* (Franke) from the Senonian of Maastricht, shows several ancestral characteristics, as the aperture shows only a very short neck, the mouth itself being elongated and somewhat loop-shaped, as in *Virgulina,* while the toothplate shows the typical form of that of *Virgulina,* with an attached part and a free folding tooth. But for the somewhat outgrown neck at the aperture, one would be inclined to believe it to be a *Virgulina,* though with thick walls. From this ancestral type the typical *Uvigerinidae* have descended, showing links in the *Angulogerinae* of the Tertiary.

Cushman created the genus *Uvigerinella.* In this genus he gathered those uvigerine forms, which show the aperture typically connected with the border of the chamber. It is possible that our genus is identical with *Uvigerinella,* but as so very little is known of this genus, as the toothplate has not yet been studied in its types, I believe it to be best to have a new genus for those forms, which show not only a somewhat virguline aperture, but also a toothplate with distinct free folded part. (See Contr. Lab. Foram. Res., Vol. 2, 1926, p. 58).

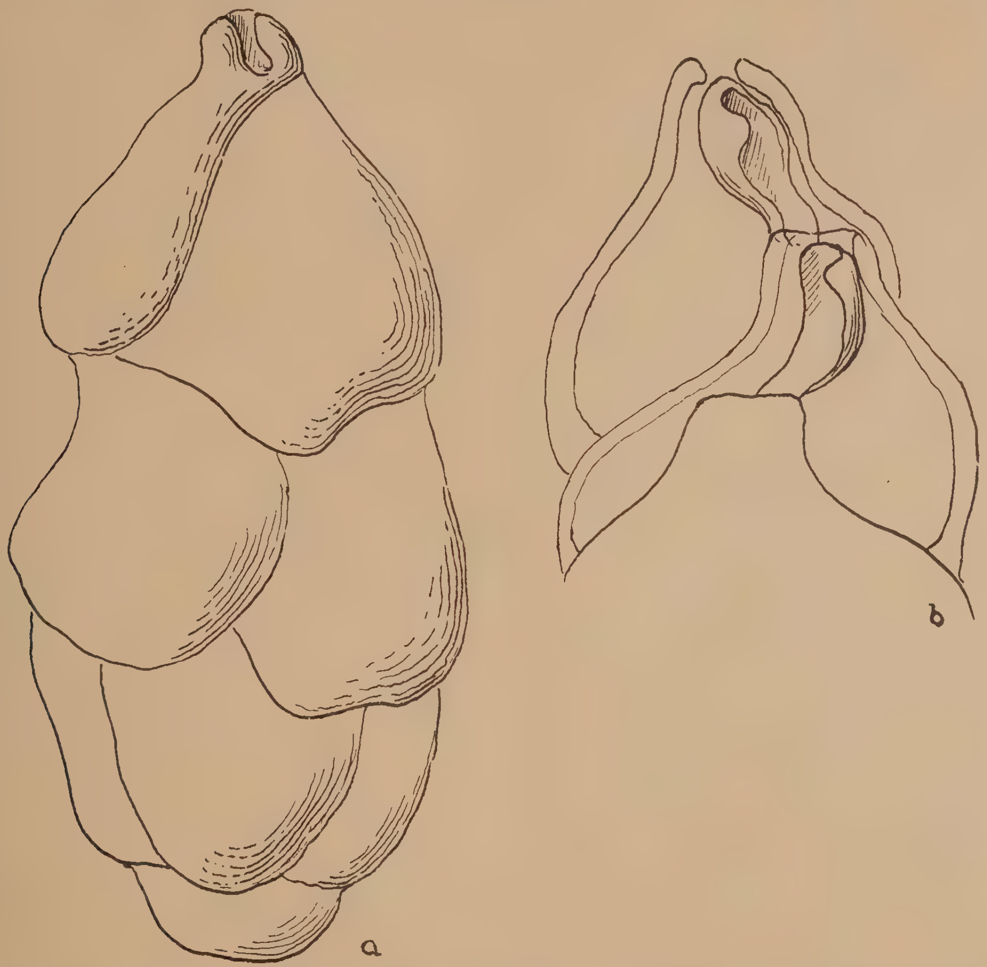


Fig. 119. *Praeuvigerina westphalica* (Franke) from the Senonian of Maastricht. a, total shell with its typical virguline aperture; b, section showing the toothplates. × 480.

Genus **Angulogerina**
(Fig. 120)

This genus was erected by Cushman for those species of the uvigerine type which show a more or less triangular transverse section. Most of the species, belonging to this genus have indeed a triangular transverse section, but often this characteristic is only very superficial. But all species of this group show an aperture with short neck, irregularly shaped lip which often is very small and unconspicuous, while the toothplate always shows the primitive character of *Praeuvigerina* (see fig. 117), with more or less developed free folded part. In *Trifarina* this folded part becomes rather reduced, as is the case in the similarly developed sub-genus *Rectobolivina* in the bolivine group. This parallelism leads to the suggestion, that the reduction of the folded part of the toothplate leads to the forming of uniserially arranged later chambers. For in another group of the *Uvigerinidae,* in the genus *Neouvigerina,* the toothplate is reduced, though in a quite different way, into a straight plate, and here too the individuals tend to become uniserial. But, as in the triserial chambers of these forms the toothplate likewise is reduced, this fact may point to the suggestion that the toothplate indicates in its form the shape of the chambers. Several discoveries in the group of the toothplate-Foraminifera lead to the conclusion, that in forming a new chamber, the toothplate is built up first, and afterwards the chamberwall is formed arround it. In this way one may understand, why the toothplate indicates the form of the chamber. But only investigations on the living animal can prove this suggestion.

In *Angulogerina* there is another typical feature: the neck of the aperture in most species, belonging to this group, shows pores, which is not the case in several other *Uvigerinidae.* So without doubt these two primitive characteristics, the shape of the toothplates and the pores on the neck, lead to the conclusion, that *Angulogerina* is the most primitive group but for *Praëuvigerina,* of the *Uvigerinidae.*

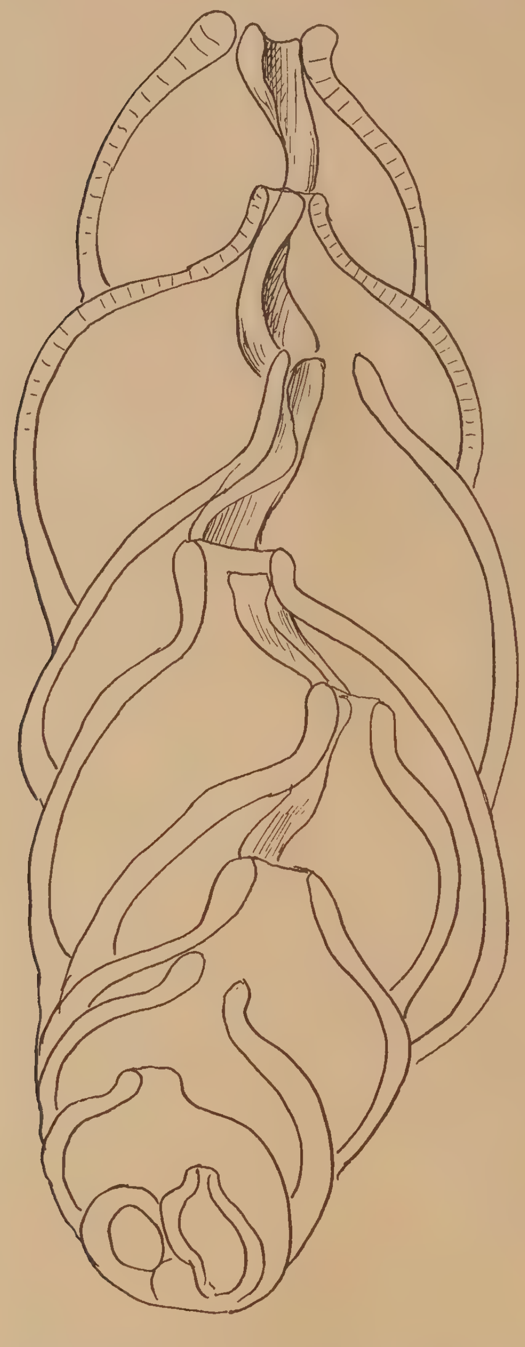


Fig. 120. *Angulogerina rugosa* from the Eocene of the Netherlands. Section, showing toothplates, their free part already reduced in respect to senonian *A. westphalica;* × 480.

Angulogerina oligocaenica (Andreae)
(Figs. 121, 122)

I found this species in abundance in samples from a drilling at America, Netherlands, from the Upper Oligocene.

The B-generation shows a proloculus with diameter of 6-10 μ; in a gathering of 32 specimens, 17 showed to be microspheric. The number of chambers in this generation was 11-17, the walls showed no or only very slight costae.

The A_1-generation shows a proloculus ranging from 20 to 40 μ, without a top. 14 specimens showed to belong to this generation. Most specimens were of a less slender type. The number of chambers was from 5 to 10. Many specimens showed no ornamentation of the walls, or only very slightly formed costae.

The A_2-generation was represented by two specimens, showing a diameter of proloculus of 60 μ. They lacked the costae nearly totally, and were of a very bulky type.

The toothplate of this species is very interesting. In most *Uvigerinae,* the toothplate forms straight plate, beginning at the outer ridge of the neck of the former aperture, and running straight p to the inner wall of the next aperture. But here all toothplates are somewhat curved, as is typical for real *Angulogerina,* while it shows the primitive folding into a free denticulated or sawed part, as is found in *Bolivina.* Its free end protrudes somewhat in the opening of the aperture, and shows likewise very fine teeth. Thus the structure of this toothplate shows the primitive character of the species, showing a texture, found in its ancestors, while in recent forms it is lacking.

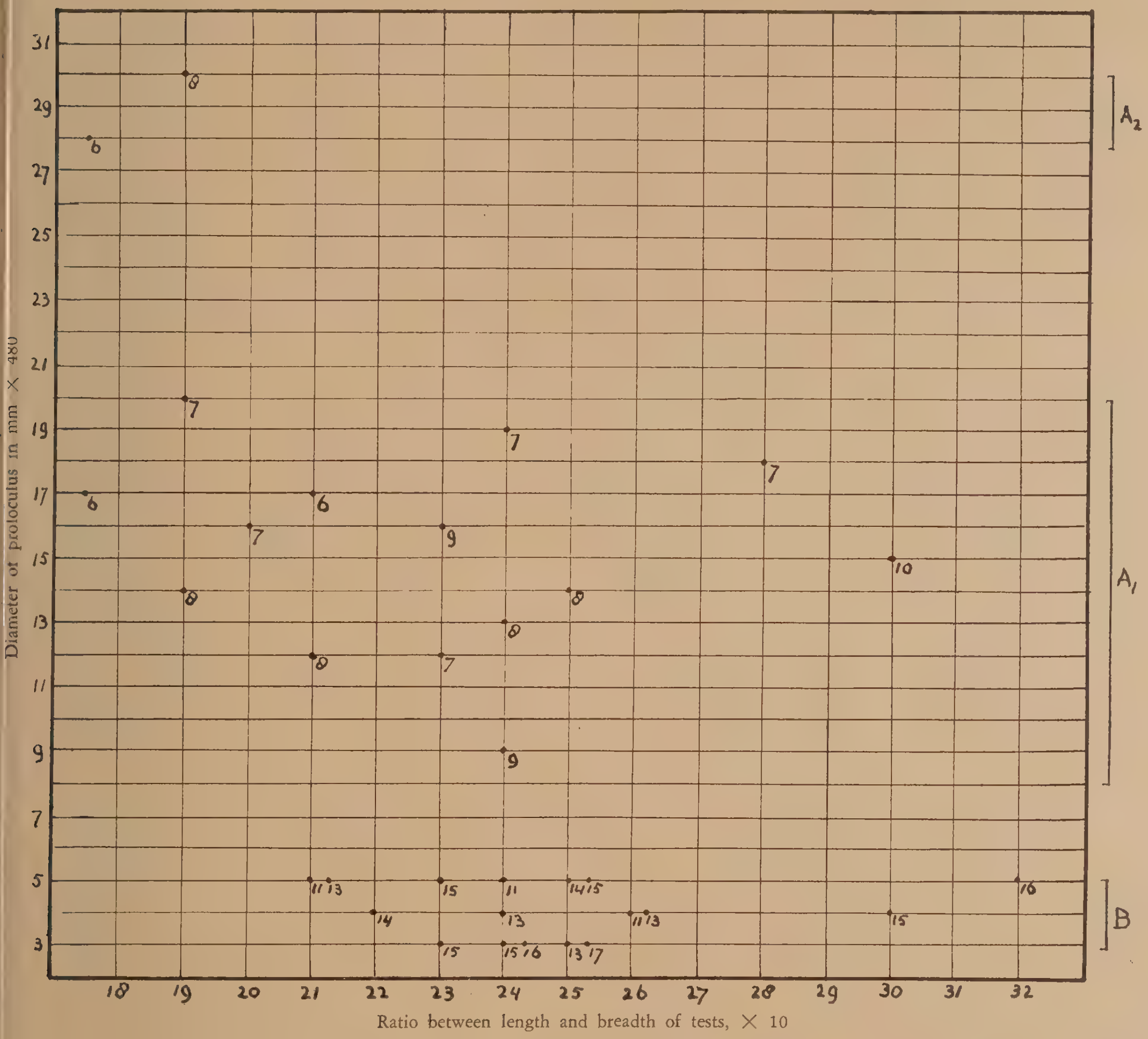


Fig. 121. *Angulogerina oligocaenica.* Diagram, showing relation between proloculus-size and the ratio between length and breadth of tests; the figures added point to the number of chambers. The diagram shows that three groups can be distinguished, each with their peculiar number of chambers. Moreover the B-forms are of a slender type, A1 is a thicker form, A2 even more.

I believe, that the species is closely allied to *Uvigerina capayana* Hodberg from the Oligocene.

The species may be closely allied to *A. albatrossi* var. *ornata* Cushman (some recent *Ang.* from the eastern Pacific, Contr. Lab. For. Res., 1932, vol. 8, pt. 2, no. 121, p. 45).

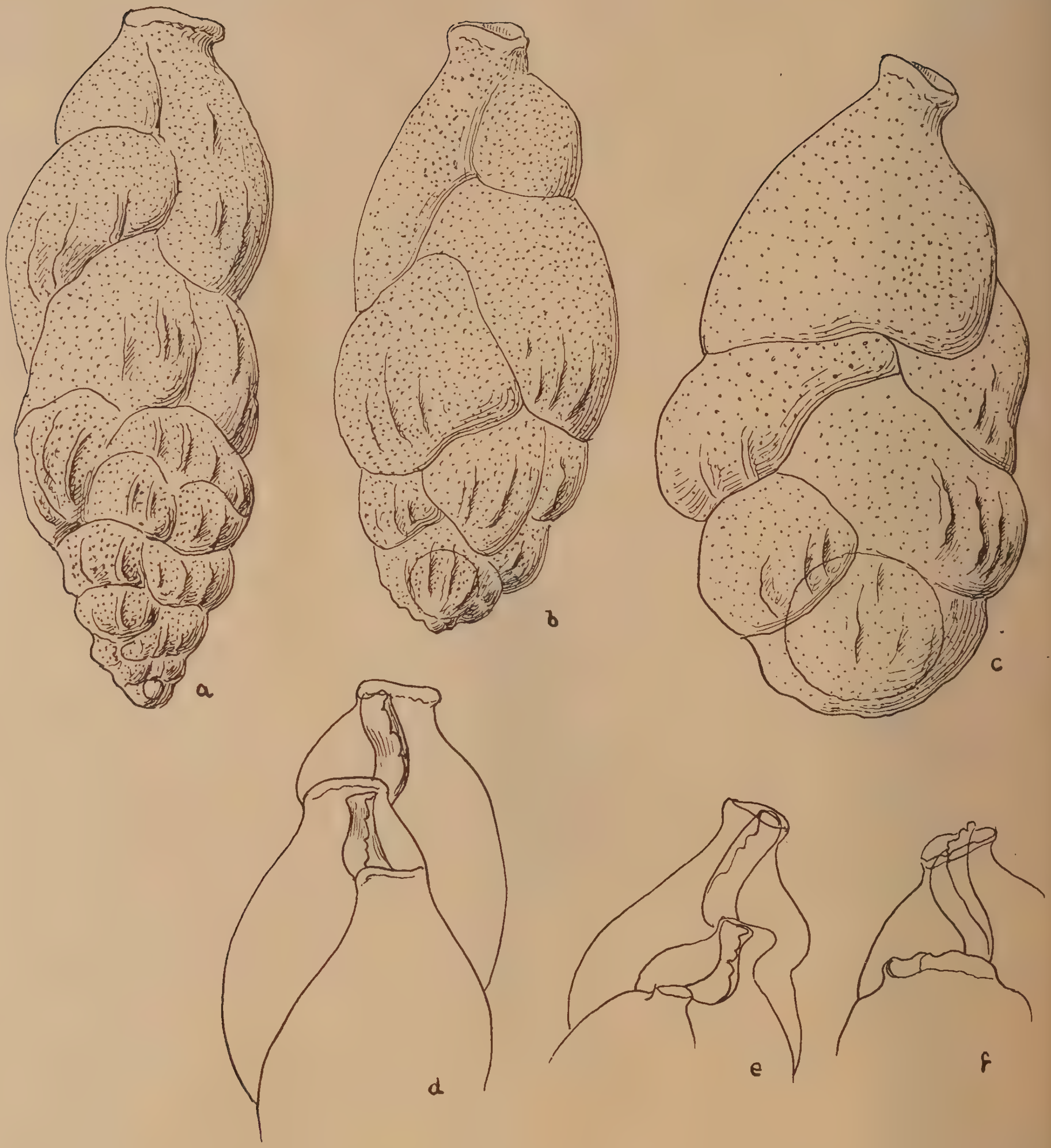


Fig. 122. *Angulogerina oligocaenica* from the Oligocene of the Netherlands. a, B-form; b, A_1; c, A_2; d, e and f, drawings of toothplates; × 440.

Angulogerina ornata Cushman

(Figs. 123-125)

A. ornata was found in only two megalospheric specimens at station 1° 51′ S., 99° 36′ E., depth 683 fathoms, and one at St. 2° 26′ S., 99° 35′ E., 582 fathoms.

Description:

Test elongate, in transverse section triangular, as each chamber shows three distinct angles, which are accentuated by distinct hyaline costae. Initial end bluntly rounded, oral end with a distinct neck which shows pores on its sides. The neck likewise is ornamented by thin costae. The aperture is surrounded by a very distinct phyaline lip. The toothplate shows the primitive character, also found in some fossil species, such as *Angulogerina oligocaenica* (Andreae) from the Oligocene of the Netherlands. It is attached by its broad base to the lip of the former foramen, and one of the sides of its base makes contact with the former toothplate. Then it runs toward the next aperture, with a broad attached part attaching itself at the inner side of the neck, but the other side is slightly folded and thus forms a free tooth, which in some apertures is seen even to protrude a little out of the aperture. In this way this toothplate shows the main characteristics of the forefathers of the *Uvigerinidae, Virgulina,* and so it is very probable, that *Angulogerina* is more primitive.

I could not find the wing, described in *Angulogerina angulosa* by Höglund (Pl. 23, fig. 8). But his whole figure does not agree with my results either, as his toothplate does not develop from the former aperture. Yet his figures of the specimens resemble in most characteristics mine, though my specimens are not costate except for the costae on the edges of the chambers. The phyaline lip of Höglund's specimen has not developed, as in the Pacific forms. As the toothplate is a much more reliable feature than outer ornamentation, I am certain, that the species described by Höglund is not identical with the species, found in the Pacific. When one loosens an endchamber from the test, one can study the toothplate from the inner side of the chamber. I found then, that this plate often creeps down with its attached part along the outer (basal) wall of the chamber, but always this flaring part, which may have been looked at by Höglund as a "wing", ends abruptly at the level of the foregoing neck. This character reminds us of the original cassidelline structure of the plate, in which likewise the attached part creeps up from the former aperture toward the inner side of the next aperture. So it will be best, to call the Pacific species *Angulogerina ornata* Cushman, which is known from deep water in the eastern Pacific (Cushman, U.S. Nat. Mus., Bull. 161, p. 57, pl. 15, figs. 10, 11).

To ascertain these differences, I studied some material, kindly given to me by Dr. van Voorthuysen from the Dutch Geological Survey, and deriving from the Earland-collection from the coast of Western Ireland. I am sure, that this material belongs to quite the same species, gathered by Höglund in the North Sea. It differs from the Pacific material in the lack of a phyaline lip around the aperture, and in some minor features in the toothplate too. But neither in this Ireland-material I could trace a wing at the toothplate, while in all specimens observed, the toothplate in the endchamber is attached to the former aperture also. The toothplate differs from the Pacific one in the fact, that it is attached lower at the former neck of the aperture, and that its flaring part is somewhat broader. May be, that Höglund regarded this somewhat flaring free and folded end as a wing (see fig. 124).

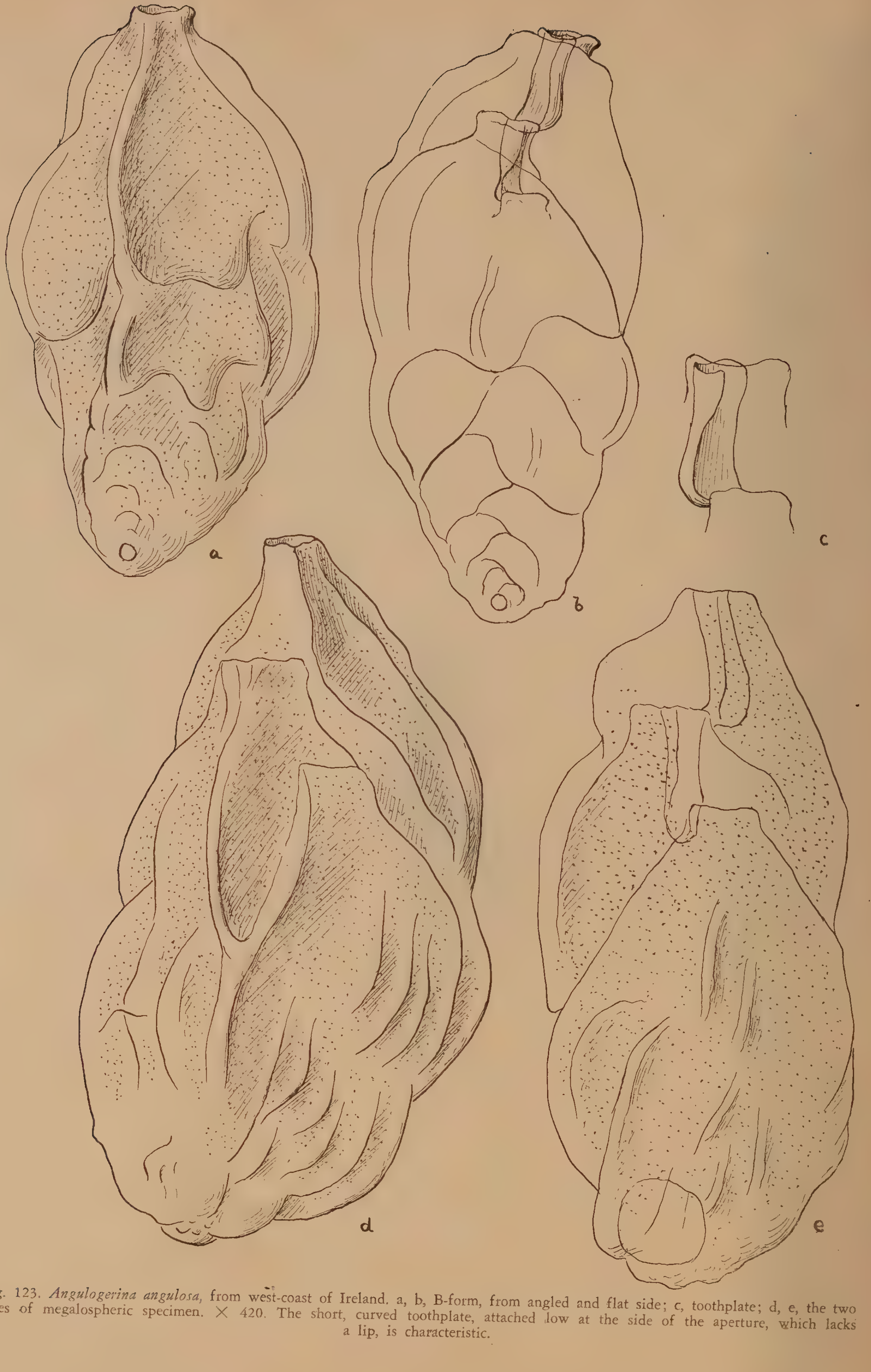
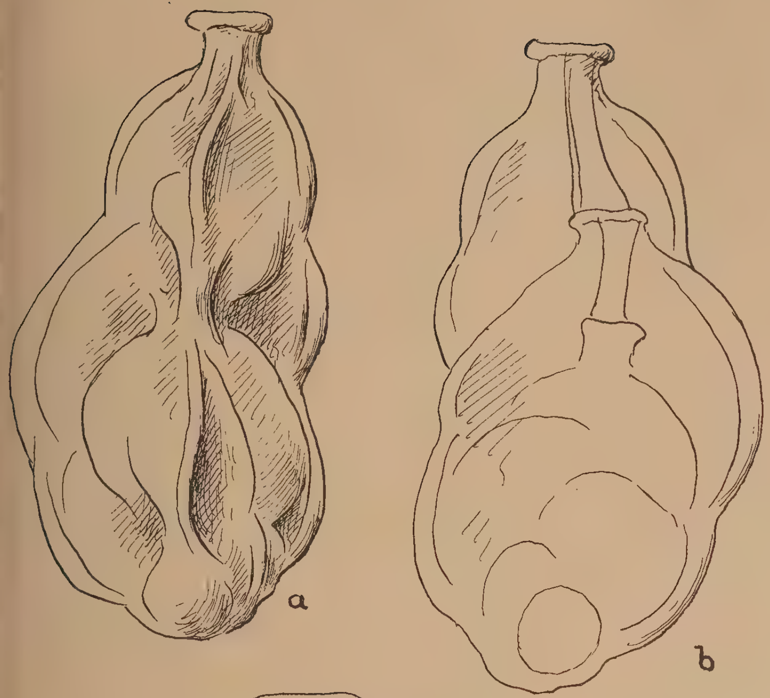
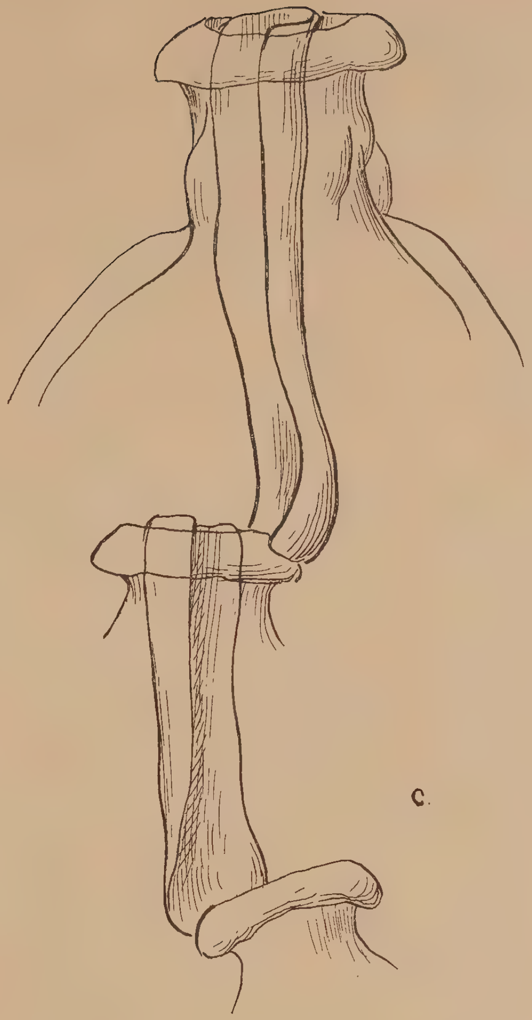


Fig. 123. *Angulogerina angulosa,* from west-coast of Ireland. a, b, B-form, from angled and flat side; c, toothplate; d, e, the two sides of megalospheric specimen. × 420. The short, curved toothplate, attached low at the side of the aperture, which lacks a lip, is characteristic.





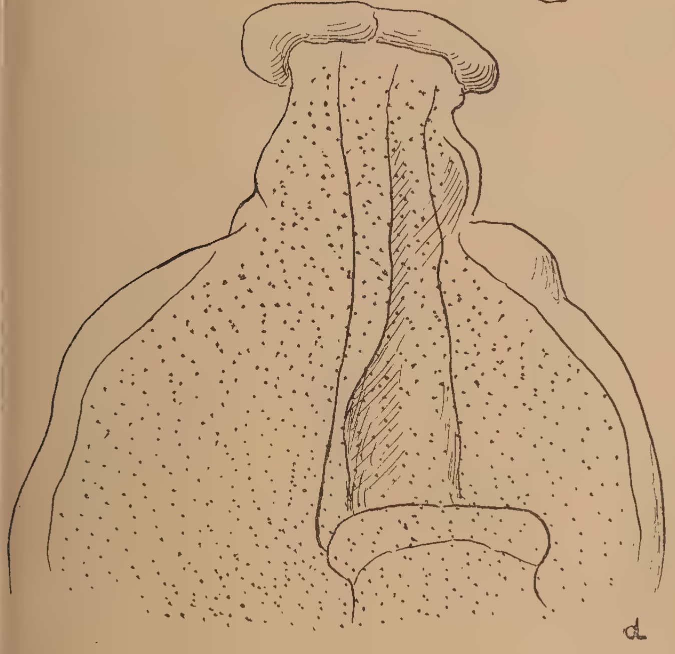


Fig. 125

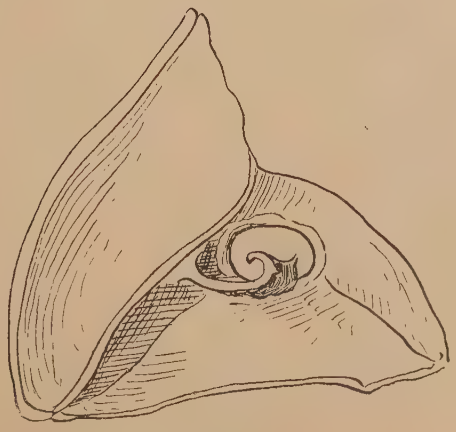


Fig. 124

Fig. 125. *Angulogerina ornata*, from the Pacific. a, b, megalospheric specimen from two sides, × 100; c, apertures with toothplates; the plates are attached on the phyaline lip of the aperture; d, apertural end with toothplate; c, and d, × 480. The whole test is much larger than that of *A. angulosa.* — Fig. 124. *Angulogerina angulosa* from coast of Ireland. Last-formed chambers, separated from test and seen from within. Toothplate shows attached part running along the outer wall of chamber, suggesting a "wing". × 480.

As the toothplate of the Atlantic specimens is differing from that of the Pacific specimens, I am inclined to separate them into two different species, though very closely allied. It is therefore, that I named the Pacific species *Angulogerina ornata* Cushman, while the Atlantic species may be called *A. angulosa* (Williamson). The size of the Pacific specimina is much larger than that of the Irish specimens. The former attain a length of 0,9 mm, whereas the Irish form shows a length up to 0,32 mm. I must point out, that Höglund, on p. 284, says, that the proloculi of B-forms measure 13-19 μ diameter; obviously he dealt with A1-specimens. The proloculus of typical microspheric specimens of the Irish material showed a diameter of only 8 μ.

Angulogerina (Trifarina) tricarinata (d'Orbigny)

(Figs. 126-130)

This species has been described by Brady as *Rhabdogonium tricarinatum* (Chall. Report. Vol. 9, 1884, p. 525, pl. 67, figs. 1-3). It was first mentioned by d'Orbigny as *Vaginulina tricarinata.* Cushman (Nat. Mus. Bull. 71, p. 3, 1913) created the genus *Triplasia* for it, and called it *Triplasia tricarinata* (p. 62, pl. 39, fig. 2). He mentioned it from Hongkong and Japan in 1921. He placed it 1928 in the subfamily *Uvigerininae,* were he had it named *Trifarina* in 1926 (Contr. Cushman Lab., Vol. I, p. 86-88).

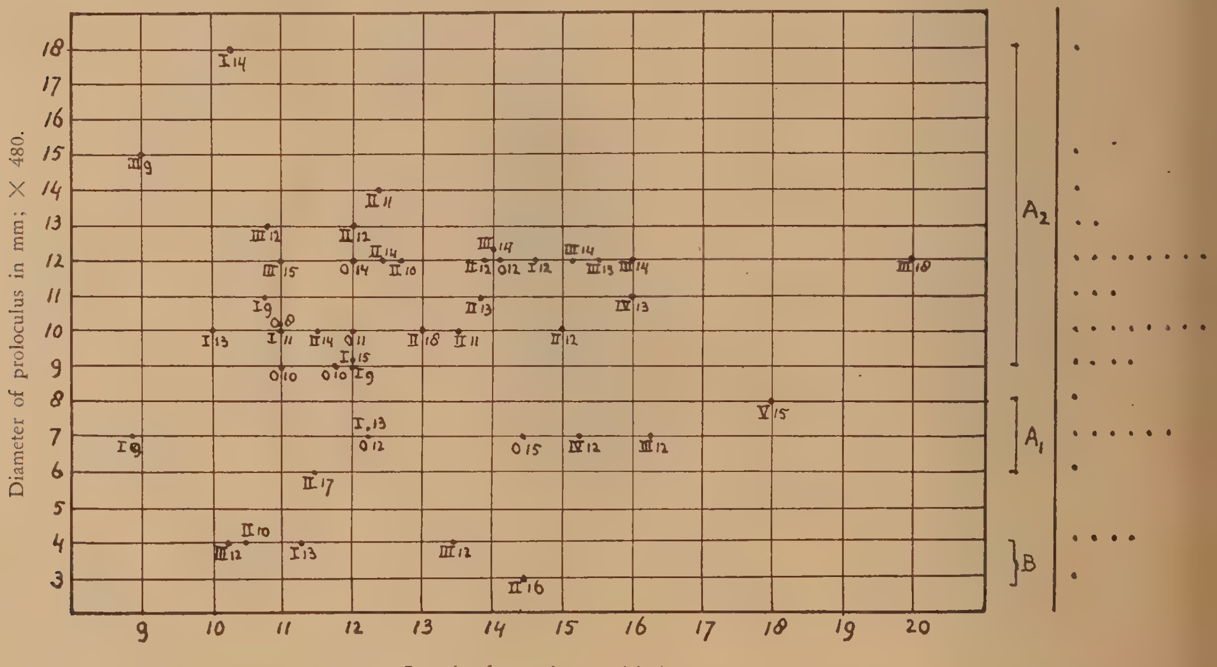


Fig. 126. *Angulogerina tricarinata.* Diagram showing relation between size of proloculus and length of tests. The roman figures give the number of uniserial chambers, the arabic giving the total number of chambers.

When we study the inner structure, we will find that, when we renounce from the triangular shape of the chambers, it shows no differences whatever from the structure of normal *Angulogerina.*

As in several species of *Uvigerina* the tendency exists to become triangular in transverse section too, there is no reason why we should create a new genus only on the tricarinate aspect of this species, the only difference being the building of a carina on the surface, which gives rise to a triangular shape of the first rows of chambers, which shape is uphold in the older rows, though these are bilocular and even unilocular (as occurs also in several other species of the genus *Uvigerina,* e.g. in *U. ampullacea.* Thus we are convinced that the species is a real *Uvigerina,* and must be called *Angulogerina tricarinata.*

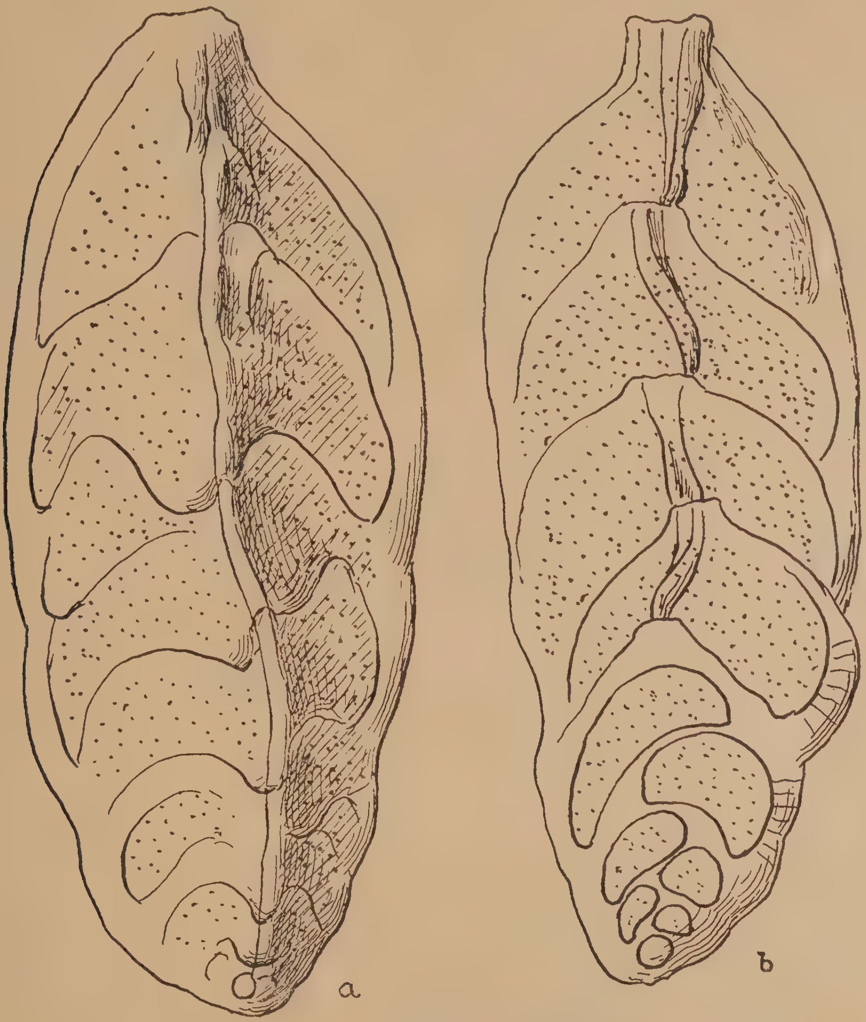


Fig. 127. *Angulogerina tricarinata.* Microspheric specimen; a, from carinate side; b, from flat side; × 480.

This species was found in larger quantities in all stations from the Van Gogh near 2° S. and 99° E., depth ranging from about 300 fathoms up to 800 fathoms. Statistical study of the specimens showed, that three groups of specimens could be separated.

B-generation. The proloculus measures from 6 up to 8 μ. It is followed by at least two rows of three chambers, then one row of two chambers, next several uniserial chambers. The total number of chambers in the 5 species found ranged from 10 to 16, the number of uniserial ones from 1 up to 4. The length of the shell is from 0,2 up to 0,30 mm, but it may be, that only young specimens were found. In the initial part of the shell the outer chamberwalls are relatively thick.

A1-generation. The proloculus has a diameter of about 15 μ. It is followed by 2 rows of

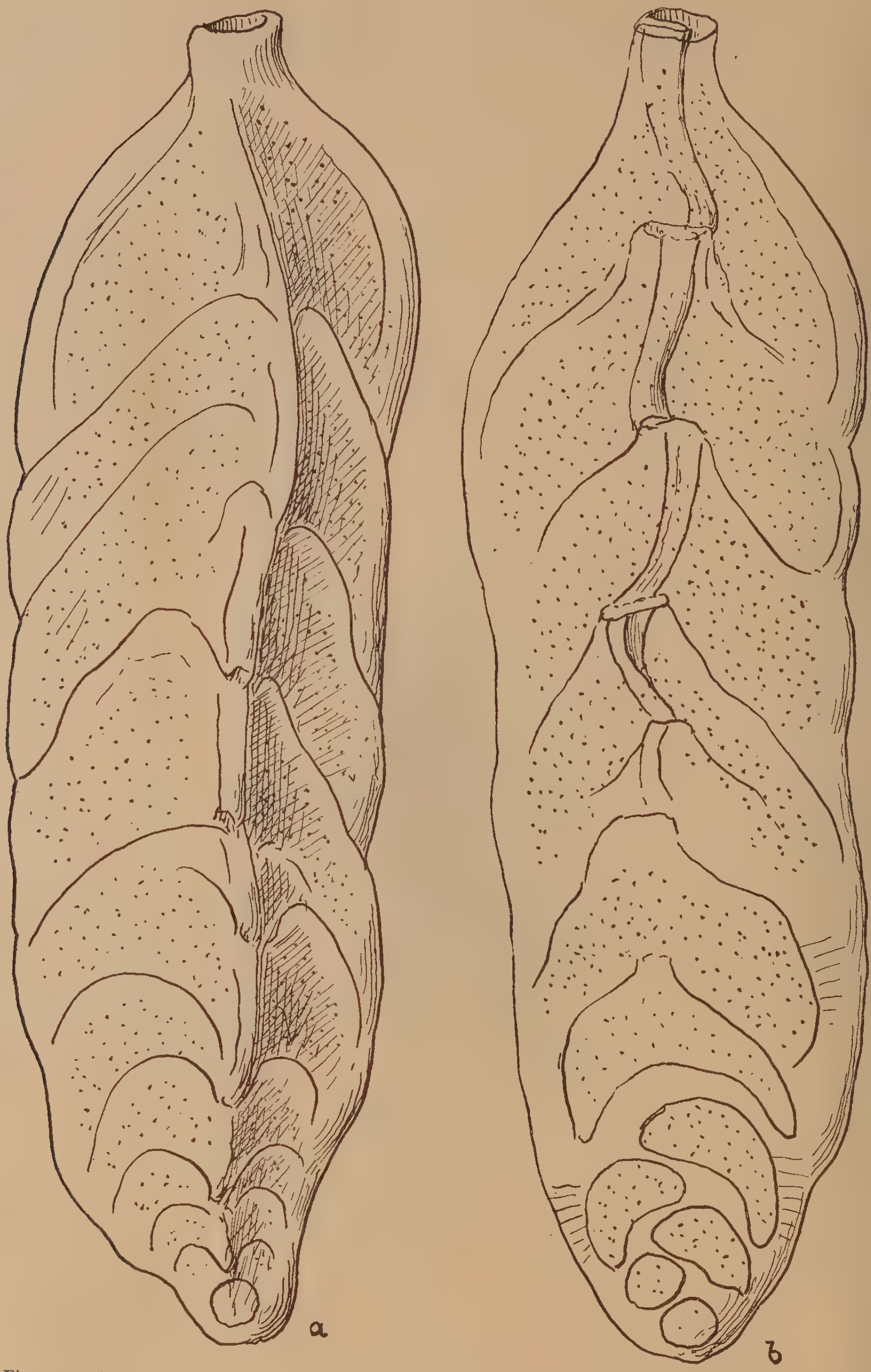


Fig. 128. *Angulogerina tricarinata.* A1-specimen; a, from carinate side; b, from flat side; × 480.

triserial arrangement, then next to it one or two rows of biserial chambers, and 1 to 4 uniserial chambers are added. The total shape of the shell is a slender one in this generation. The length of these shells, 8 of which were found, ranges from 0,2 up to 0,33 mm.

A_2-generation. This generation forms the bulk of the material, as 31 specimens could be analysed. The proloculus has a diameter of 18-37 μ, and is followed by two rows of triserial chambers, to which two or three rows of biserial chambers are added. Uniserial chambers occur too in outgrown specimens, most of them showing 2 or 3 of them. The total length of the shell in this generation is from 0,23 up to 0,37 mm, but most of them have a length of about 0,25 mm.

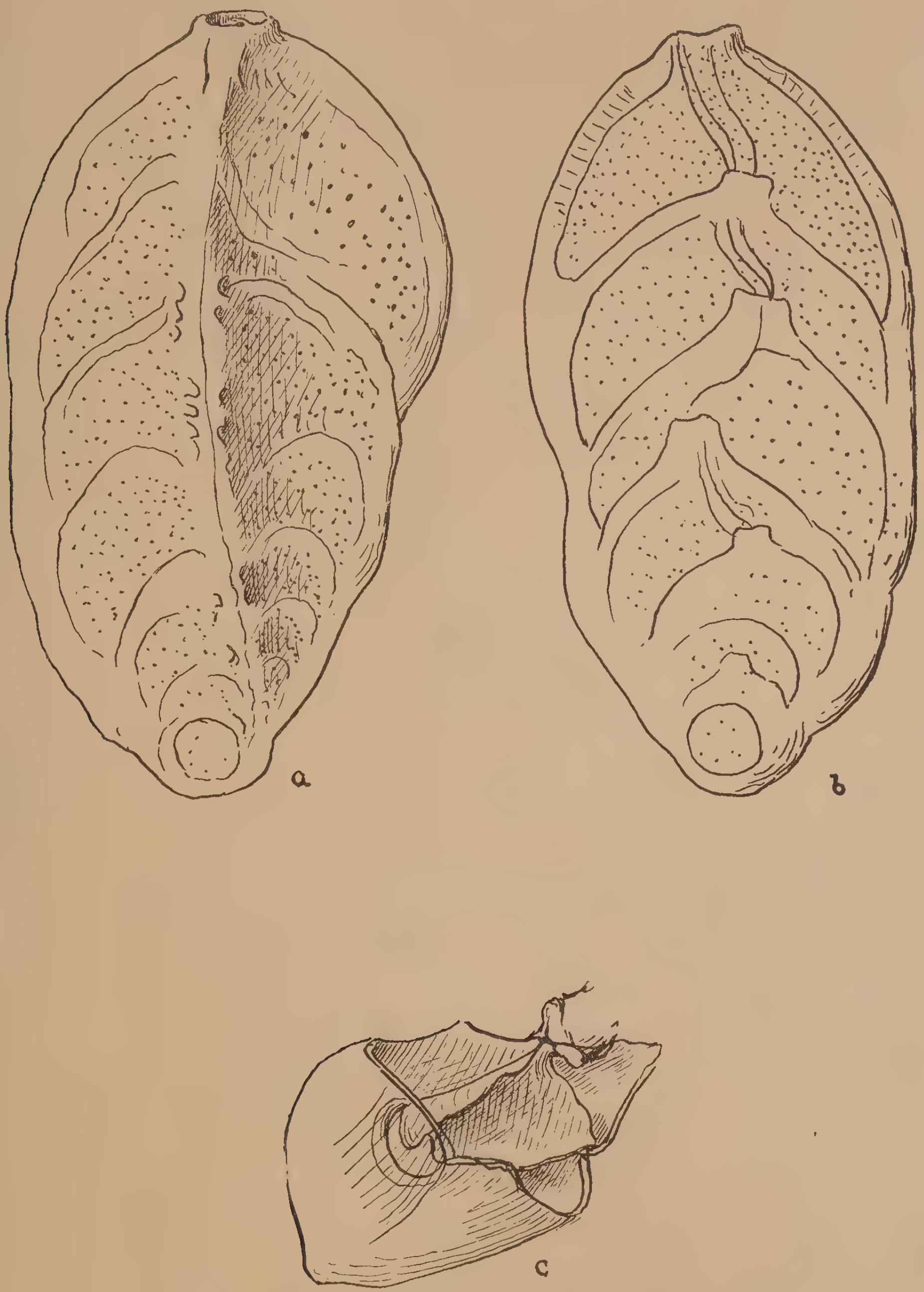


Fig. 129. *Angulogerina tricarinata.* A_2-specimen; a, from carinate side; b, from flat side; × 480; c, last-formed chamber loosened from the test, and seen from within, showing toothplate, with attached part running down along outer wall and forming a kind of „wing".

There are but slight differences in shape between the three generations, the A_2 shells in-

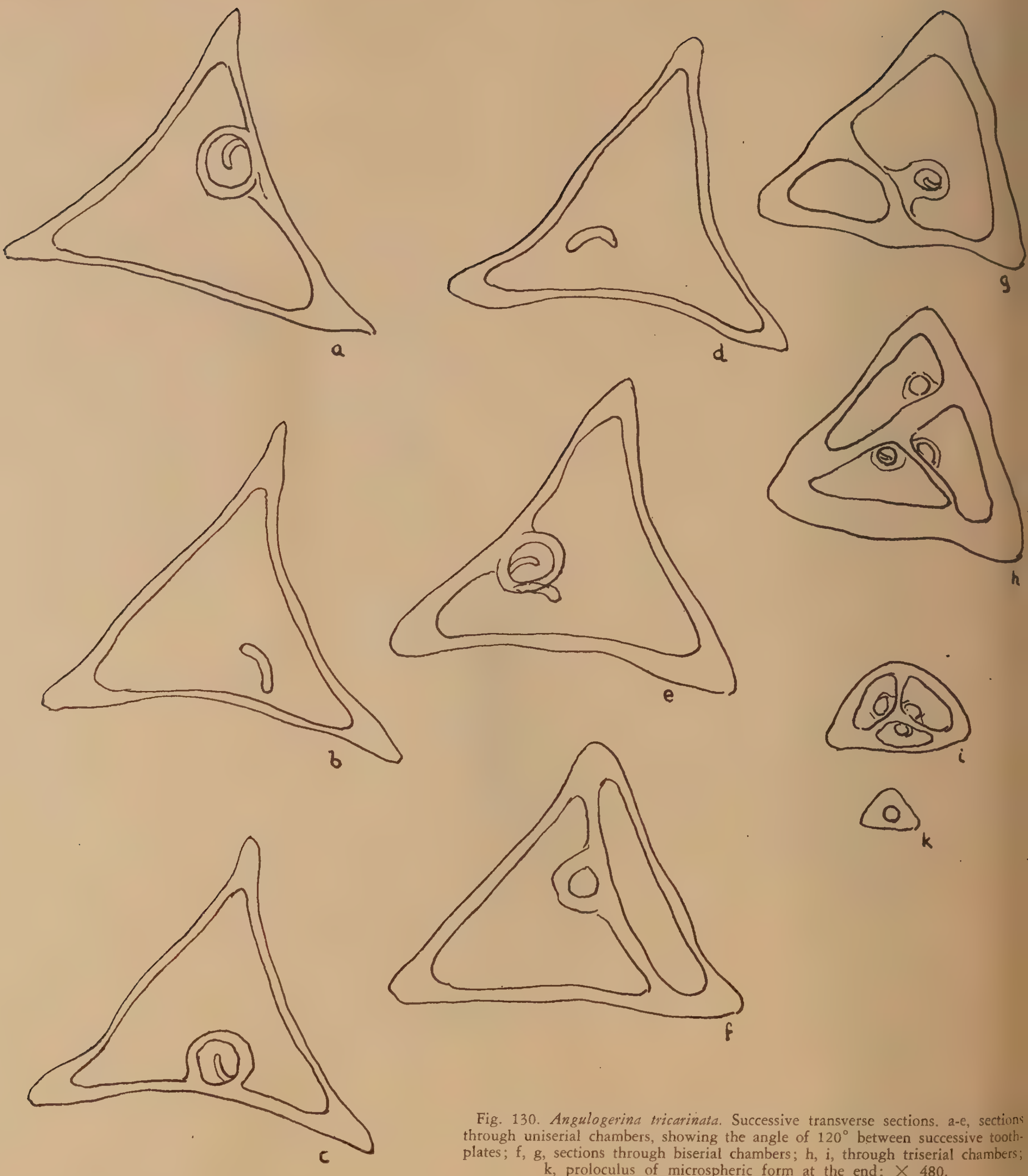


Fig. 130. *Angulogerina tricarinata.* Successive transverse sections. a-e, sections through uniserial chambers, showing the angle of 120° between successive tooth-plates; f, g, sections through biserial chambers; h, i, through triserial chambers; k, proloculus of microspheric form at the end; × 480.

creasing in breadth towards the apertural end, while the two other forms show nearly parallel sides.

Transverse sections show, that the proloculus possesses a mouth which is found in the centre of the proloculus, and that this proloculus shows already the somewhat triangular outer surface.

The next three chambers show the three separating walls running towards the carinae, and the mouths of them are situated along the inner edges of those walls. In the next row of triserial arrangement these separating walls run alternating with the former ones, but here too the apertures are situated near the centre of the shell. In the biserial rows of chambers the apertures likewise are situated along the inner separating wall, and here one observes the typical Uvigerine feature, that the outer part of the wall of the apertural neck is found in the chamberwall itself. The toothplate in these apertural necks is fastened at one side, is somewhat curved, and adheres in all chambers in such a way, that it forms an angle of nearly 120° with the former and the next one. This plate runs from the phyaline lip of the former aperture through the lumen of the chamber obliquely towards the opposite inner wall of the next aperture, thus describing a zig-zag-line, as is the case in all Uvigerine shells. In the uniserial chambers the chamber itself is triangular, and the apertural neck of the former chamber runs along the middle of one of the chamberwalls, building with its outer side part of the wall. In each next chamber the neck is situated at another side of the shell, thus forming with that of the former chamber an angle of 120°. And here the toothplate is always attached at the outer wall of the neck. This is in the same wise as in *Neouvigerina ampullacea.*

2° 6′ S., 99° 54′ E., depth 778 fathoms.

In several outgrown specimens the toothplate of chambers of the triserial part showed a broadening toward the outer wall of the attached part of the plate, suggesting a "wing". This shows, that the original structure of the toothplate is identical with that of *Bulimina* and *Cassidella,* the attached part creeping up along the outer (basal) wall. But this is no wing in the sense of Höglund (1947). For that wing is an additional part, found in the genus *Aluvigerina,* starting from the folded back of the toothplate. Here it is formed only by the attached border of the plate.

Angulogerina occidentalis (Cushman)
(Fig. 131)

This small species occurred at St. 10° S., 123° 19′ E., depth 453 fathoms and 8° 15′ S., 118° 56′ E., depth 340 fathoms. I found micro- as well as megalospheric specimens. It has been sufficiently described by Cushman (Bull. 161, U.S. Nat. Mus., 1941, p. 58) as follows:

"Test minute, elongate, triangular in transverse section, the periphery somewhat lobulate; chambers distinct, those of the last-formed portion becoming more distinct and remote; sutures distinct and depressed; wall ornamented with longitudinal costae on all but the last-formed chambers in the adult; apertural end drawn out into a short tubular neck and slight phialine lip. Length 0,30 mm, diameter 0,12 mm".

Most specimens I found were slightly smaller than those, mentioned by Cushman. B-specimens show more irregularly shaped costae than the A-forms.

The toothplate is somewhat more reduced than in other *Angulogerina,* as its folded tooth is nearly totally absent. In this way it can be easily distinguished from other small costate forms. The toothplate is long, straight and narrow, and lacks any trace of a wing. Thus it resembles that of *Euuvigerina.*

Genus **Aluvigerina**

In this genus the toothplate shows at its dorsal side a wing, first discovered by Höglund in a species, found mainly in the Skagerak, and named by him abusively *Uvigerina peregrina*

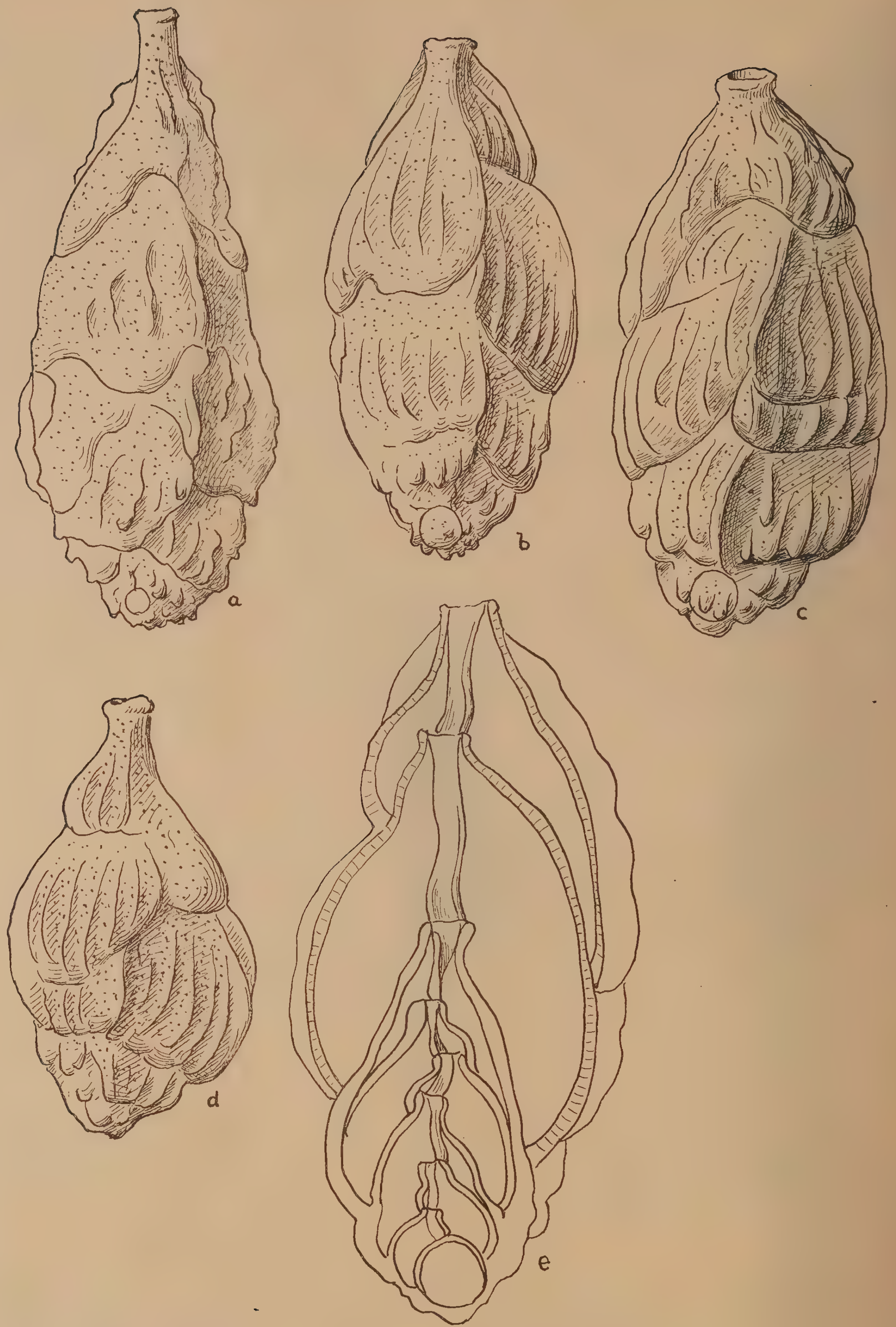


Fig. 131. *Angulogerina occidentalis.* a, Microspheric specimen; b and c, A_1-form; d, A_2-individual; *e*, section, showing toothplates. a-d × 480, e × 630.

Cushman. I will try to analyse all costate species when dealing with *Euuvigerina peregrina,* but here I will describe *Aluvigerina pygmaea,* as it occurs in the Adriatic, and as it has been mentioned many times from the Pacific, though I could not find a single specimen in my material.

Aluvigerina shows an aperture with neck, mostly lacking pores, thus indicating, that it belongs not to the group of *Angulogerina.* The toothplate shows the normal form, but for the wing. It is a more or less straight plate, beginning at the former neck, and running straight up to the next neck, attaching itself to its inner wall. But at the dorsal side of the plate is found a thin plate, a wing, as Höglund called it, which divides partly the chamber into two parts. Höglund describes it as follows: "The apertural tongue divides the anterior portion of the apertural neck into two parts, and as the tongue is fused to the inner side of the shortest chamberwall, the anterior portion of the chamber is also separated into two departments. Downwards the tongue is coalescent with one border of the foramen neck of the preceding chamber. Sometimes the whole upper part of the chamber and of the apertural neck is completely divided into two halves by the apertural tongue being equipped with a vertical wing arised from the convex margin of the tongue and extending across to the opposite, posterior chamberwall."

Until now only a single species is known to possess this wing, viz. typical *Aluvigerina pygmaea* from the Adriatic, while it is probable, that Höglund's species, named by him *Uv. peregrina,* is a different species of the group. This species is not identical with my *Uv. mediterranensis,* as Höglund suggested, and has nothing to do with *Euuvigerina peregrina,* as I shall show further on. Höglund meant to trace such a wing in *Angulogerina angulosa* too, but I could not state this view in my material, neither in any of the species of *Angulogerina.*

Aluvigerina pygmaea (d'Orbigny)
(Fig. 132-133)

The species occurs abundantly in a gathering at the beach at Rimini, Adriatic. I am convinced, that this species is the same d'Orbigny found in a fossil state at Siena, though it may be, that the Adriatic form is somewhat smaller in its total size. But the fact, that d'Orbigny called it *pygmaea,* shows clearly, that he was struck by the smallness of the tests. This is in agreement with the species, found in the Adriatic.

Description.

Costae fine, without granulations; neck with or without phyaline lip, often without; neck with fine granulations or with costae, but never with pores as in *Angulogerina.* At the initial part costae often replaced by granulations. Toothplate with a dorsal wing. Endchambers often with granulations, which replace costae. Length in B-form 0,45 mm, in A_1 up to 0,35 mm, in A_2 up to 0,35 mm.

The total shape of the species is very variable; in the microspheric form it is elongate, and the largest breadth is near the apertural end; in the A-forms the initial part is often rounded, and the largest breadth is near the middle of the test.

Höglund's species (1947, p. 279-283) is a larger one, length of A_1 (mentioned as B) up to 1,4 mm, that of A_2 (mentioned as the megalospheric form) up to 0,9 mm. The shape of his toothplate is very much resembling that of the Adriatic form, but for the fact, that the wing in the Skagerak-form is shorter and not so well developed. Thus Höglund's species may be quite a different species of the genus *Aluvigerina.*

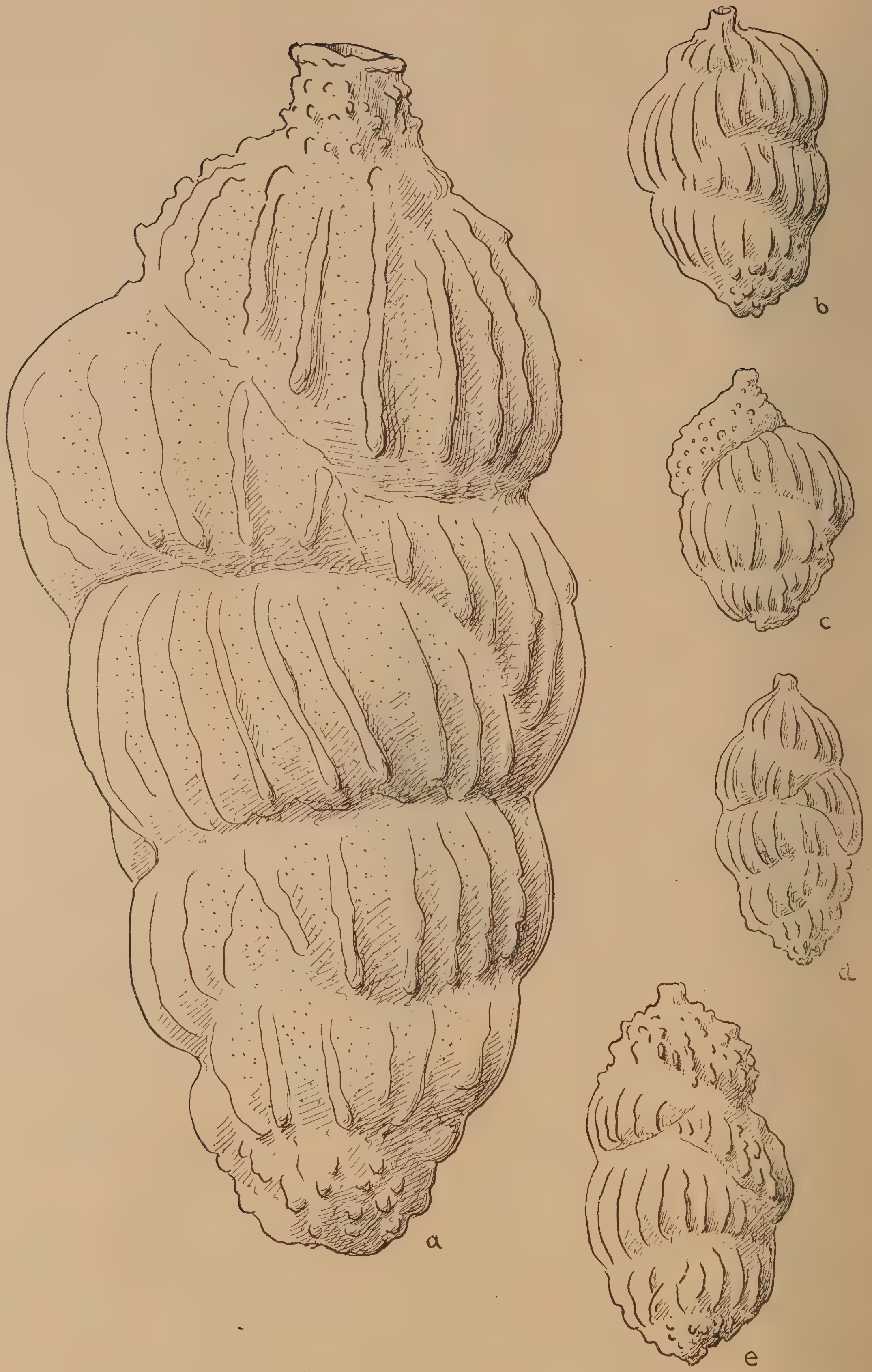


Fig. 132. *Aluvigerina pygmaea.* a, megalospheric specimen, × 460. b-e, several forms, enlarged × 96.

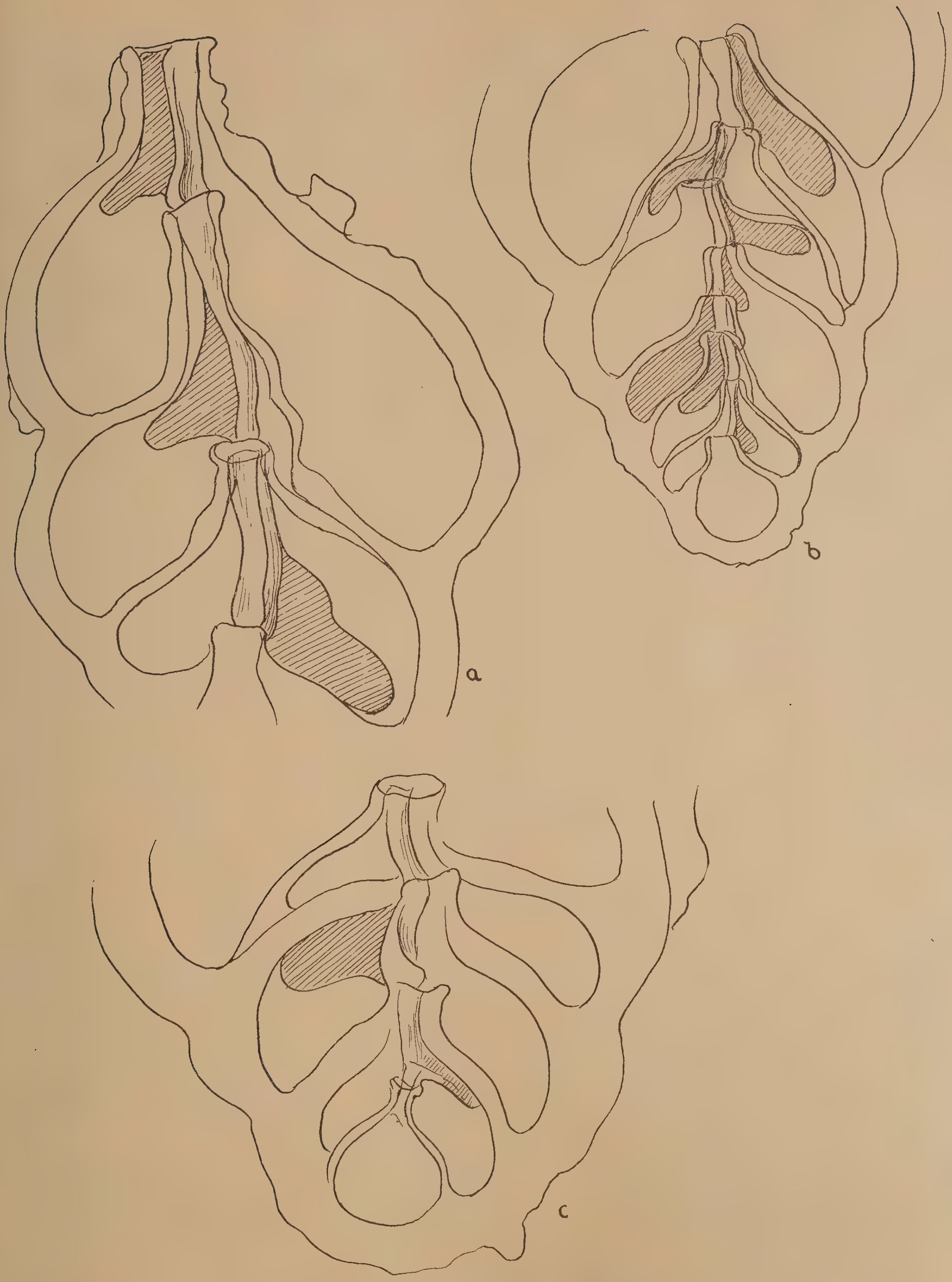


Fig. 133. *Aluvigerina pygmaea.* a, section through apertural end, showing toothplates with wings; b, initial part, showing the same; c, initial part, showing neck and phyaline lip of the proloculus; × 440.

Cushman in his discussion on *U. pygmaea* (Contr. Lab. For. Res., Vol. 6, pt. 1, 1930, p. 62) says: "The figures given by Soldani and referred to by d'Orbigny are not well drawn, but show apparently a somewhat thicker, coarser test with fewer and heavier costae, evidently the form now fairly common at Rimini on the Adriatic." But, as I have already shown in several instances, the coarseness of the test and the shape and number of costae are such variable characteristics within a species, that they cannot have any specific value. It is therefore that I identified the Rimini-species, here described, with d'Orbigny's *Uvigerina pygmaea.*

Aluvigerina indonesiae nov. spec.

(Fig. 134)

This small species occurred in several specimens in the stations 8° 11′ S., 118° 43′ E., depth 1015 fathoms, and 8° 15′ S., 118° 56′ E., depth 340 fathoms. At small enlargement it resembles somewhat *U. ampullacea,* but at higher magnification it is quite different from that species. The test is somewhat ovally formed, with the greatest breadth about the middle. Chambers inflated, with rather deep sutures. Neck short and wide, with pores, and a very thin phyaline lip. Pores very fine, covering the whole surface, surface without any ornamentation. In this character it resembles *U. canariensis,* but for its much smaller size. Yet it is very peculiar, that Millet says, *U. canariensis* is to be abundantly found in the region, while I myself did not find even a single specimen of that species. The toothplate is rather peculiar. It is attached with its whole base at the apertural lip of the former chamber, runs upward to form a folded tooth, and shows a short and narrow wing at its dorsal side. This indicates, that in this species we have a link between real *Aluvigerina* and typical *Neouvigerina.* For the narrowed wing is attached somewhat lower than the lip, and has already the shape of that of *Neouvigerina.* The discovery of this species shows, that in reality the *Neouvigerinae* can be derived from *Aluvigerina.*

Though only few specimens were found, I have given the species a name, as it is such a remarkable one.

Length up to 0,25 mm, breadth up to 0,13 mm.

Genus **Neouvigerina**

In this genus I gather all those species, which show a toothplate consisting of a more or less straight, simple plate, not attached with its whole base to the lip of the former aperture, but only with its side to the outer side of the former aperture. This situation of the toothplate indicates, that it has been developed from a winged plate, the real plate of which is reduced and only the wing remained. This wing has now taken over the function of a toothplate. All species belonging to this group show more or less developed granulations on the surface, in some cases melting together into irregular costae. They all show a long neck at the aperture, and seem to be of a late date of development; this neck, however, shows a primitive character, as it is nothing but the apertural part of the chamber, drawn into an elongation, as its walls show pores. They are found probably from the Oligocene upward. They show the tendency to become uniserial in the end, leading thus to *Siphogenerina* (which may be no real genus, as it developed in a multi-ancestral way). The species, most allied to *Neouvigerina* seems to be *Aluvigerina indonesiae.*

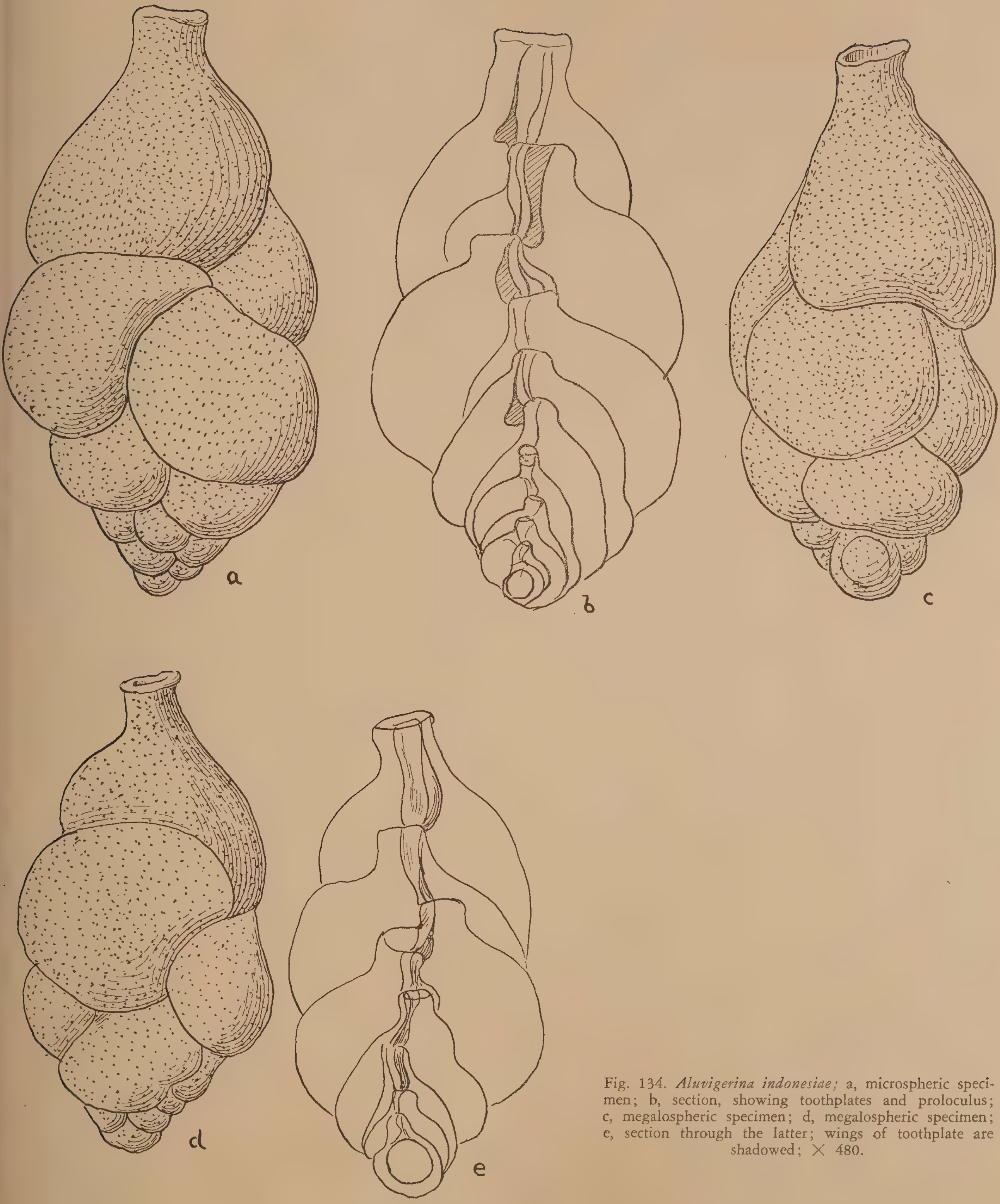


Fig. 134. *Aluvigerina indonesiae;* a, microspheric specimen; b, section, showing toothplates and proloculus; c, megalospheric specimen; d, megalospheric specimen; e, section through the latter; wings of toothplate are shadowed; × 480.

Neouvigerina ampullacea (Brady)

(Figs. 135-138)

In several stations from the Steamer Van Gogh South of Sumatra occurred in some abundance small *Uvigerinae,* which showed in some cases the typical uniserial arrangement of the last-formed chambers, typical for *U. ampullacea.* 42 specimens were statistically analysed, all of a single station. The length of the shell showed three tops, the largest breadth a single top, the diameter of the proloculus three tops, and three distinct groups.

B-generation. All proloculi of 9 specimens had a diameter of 6 μ. The length of the shell was from 0,31 mm up to 0,5 mm, the breadth from 0,13 mm up to 0,21 mm. The shell showed relatively large spines which gave the shell the total aspect of *Neouvigerina asperula.* The number of the chambers ranged from 11 in the smaller specimens (young ones) up to 19 in fullgrown specimens, with an average of 16 chambers. They are throughout arranged in coils of three chambers, so the typical uniserial arrangement does not occur in the B-form. Only some specimens showed the tendency to become uniserial, by way of a biserial arrangement of the last-formed chambers. Most specimens show a compact and rounded habitus. Especially the larger specimens show the development of a spinous surface.

A1-generation. The proloculi of the generation have a diameter from 10 μ up to 17 μ. The length of the shell ranges from 0,25 mm up to 0,48 mm and the breadth from 0,09 up to 0,18 mm. The shell shows much smaller development of spines, those of the initial end being the larger ones. This generation shows the typical features of *N. ampullacea.* 12 specimens were found in the material. These specimens show 7 up to 15 chambers, with an average of 10 chambers. Adult specimens show the tendency to become uniserial, but most of them are at the apertural end biserial, some with a single uniserial chamber at the top.

A2-generation. The proloculi measure from 27 up to 56 μ diameter, in 21 specimens found. The length of the shell was from 0,18 up to 0,35 mm, but some uniserial shells showed a length up to 0,5 mm. The largest breadth is from 0,07 up to 0,16 mm. The shell shows few spines, most of them very short, like little pustules. Only at the sutures the spines may be somewhat larger and sharper. Typical is the looseness of the building of the shell, due to the fact, that only the three first-formed chambers after the proloculus show the triserial arrangement, so that they are all three cut when a transverse section is made, while the next chambers are arranged in the biserial type, so that only two of them are cut in transverse section. In fullgrown specimens two chambers may be added in typical uniserial arrangement, which gives the type of *Neouvigerina interrupta.* The number of chambers ranges from 5 in young specimens up to 9 in fullgrown ones, with an average of 7 chambers. Only the young specimens show the compact habitus, and thus the total shell has yet the characteristic of *N. ampullacea* in the initial part of the shell.

Inner structure. A peculiar toothplate runs into the long neck with its phyaline lip. It is fastened at one side to the inner surface of the neck, while the other side is folded over, in such a way that in transverse section through the neck a short spiral is seen. The neck becomes oval in transverse section towards its base, and then the plate runs back into the lumen of the chamber till it reaches the outer wall of the next neck. Here it adheres and ends abrubtly with a rounded border. In this next neck the toothplate is fastened at a side, making an angle of just 120° with the formerly described plate, when the chambers are situated in the biserial or triserial arrangement. In the

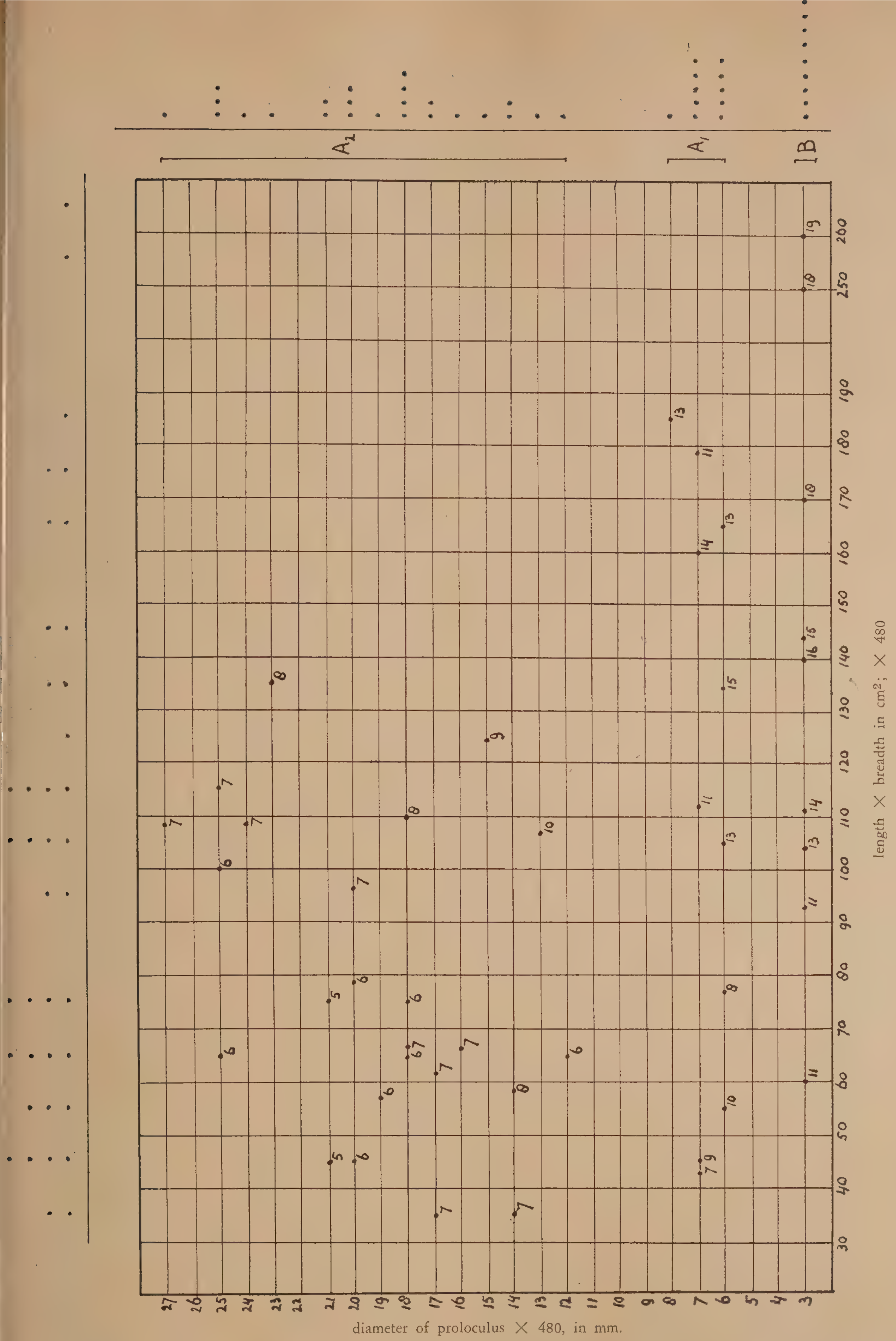


Fig. 135. *Neouvigerina ampullacea.* Diagram, showing relation between diameter of proloculus and product of length and breadth. The figures added indicate the total number of chambers. This number ranges in B from 11-19, in A1 from 7-15, in A2 from 5-10. The total length decreases, when the size of the proloculus increases.

uniserial one, however, the toothplates make angles of even 180° with each other. Each chamber is built up against the neck of the former one, and the outer wall of that neck forms the outer wall of the chamber at this side also. This is the case in all kinds of arrangement of chambers. The first chamber shows a very short and thinwalled neck just in the centre of the chamber, when seen in such a way, that the shell is looked at just on its apertural end. The toothplate fails in this neck.

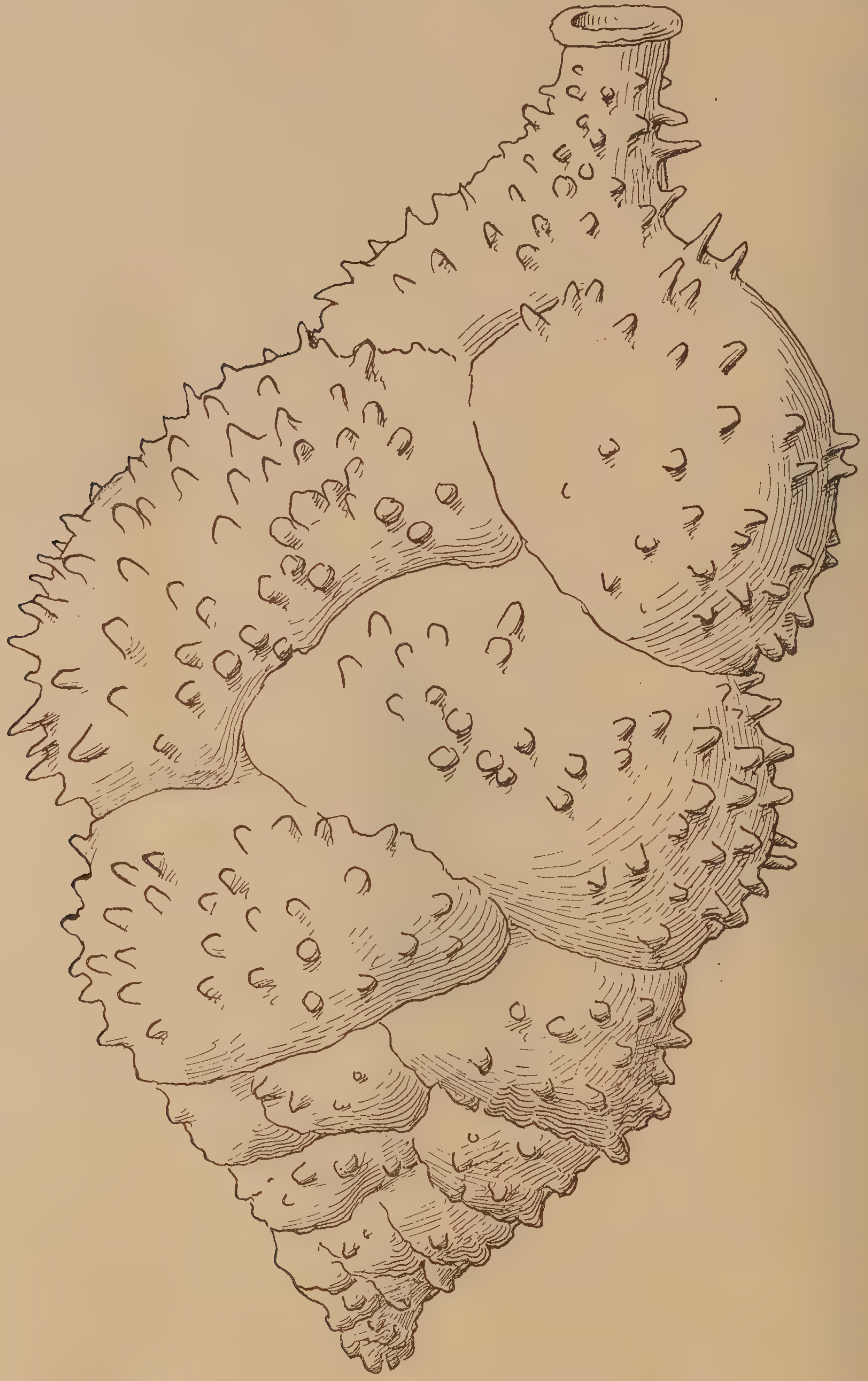


Fig. 136. *Neouvigerina ampullacea.* Microspheric specimen. × 480.

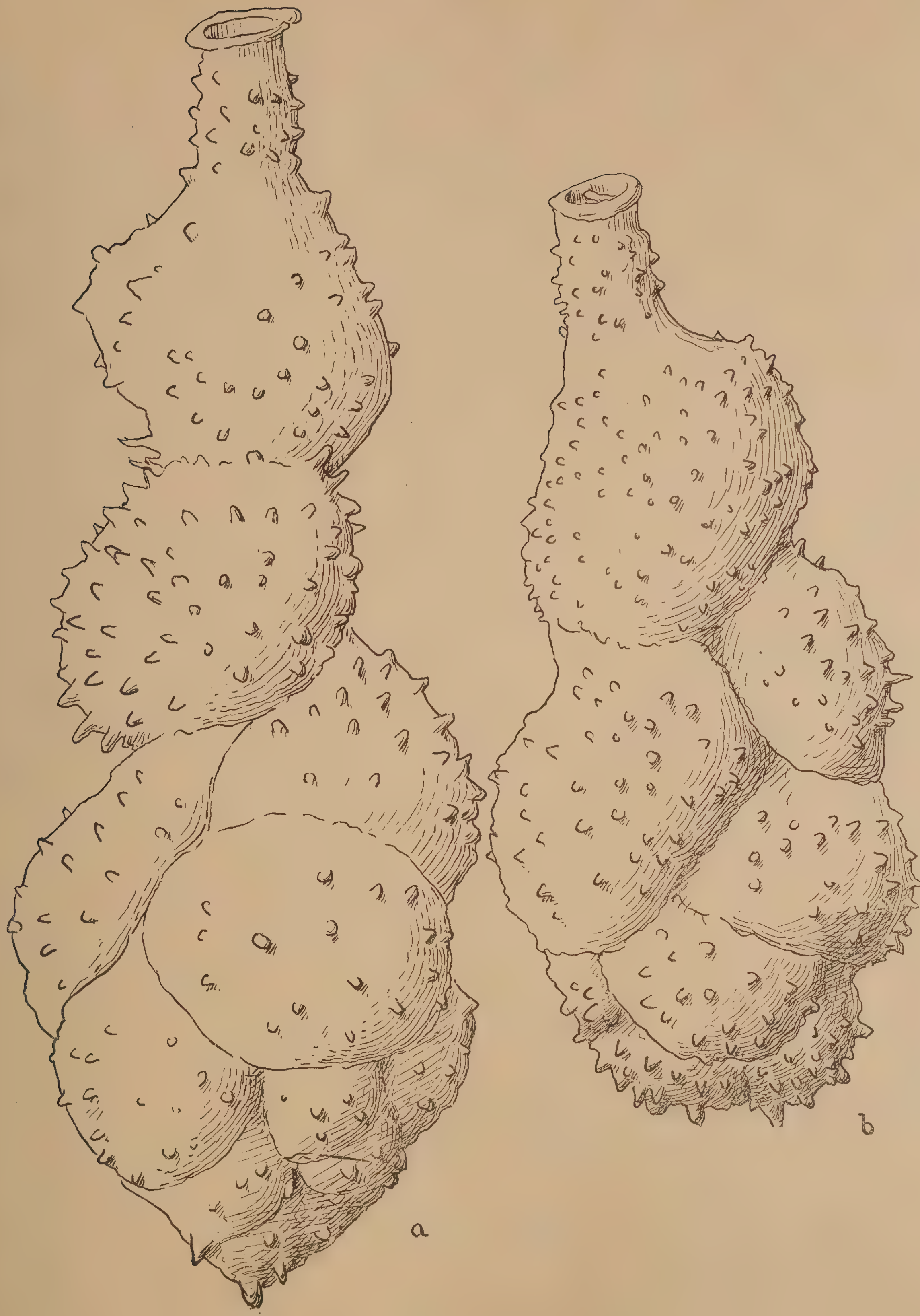


Fig. 137. *Neouvigerina ampullacea.* a, individual of A1-generation; b, specimen of A2-generation. × 480.

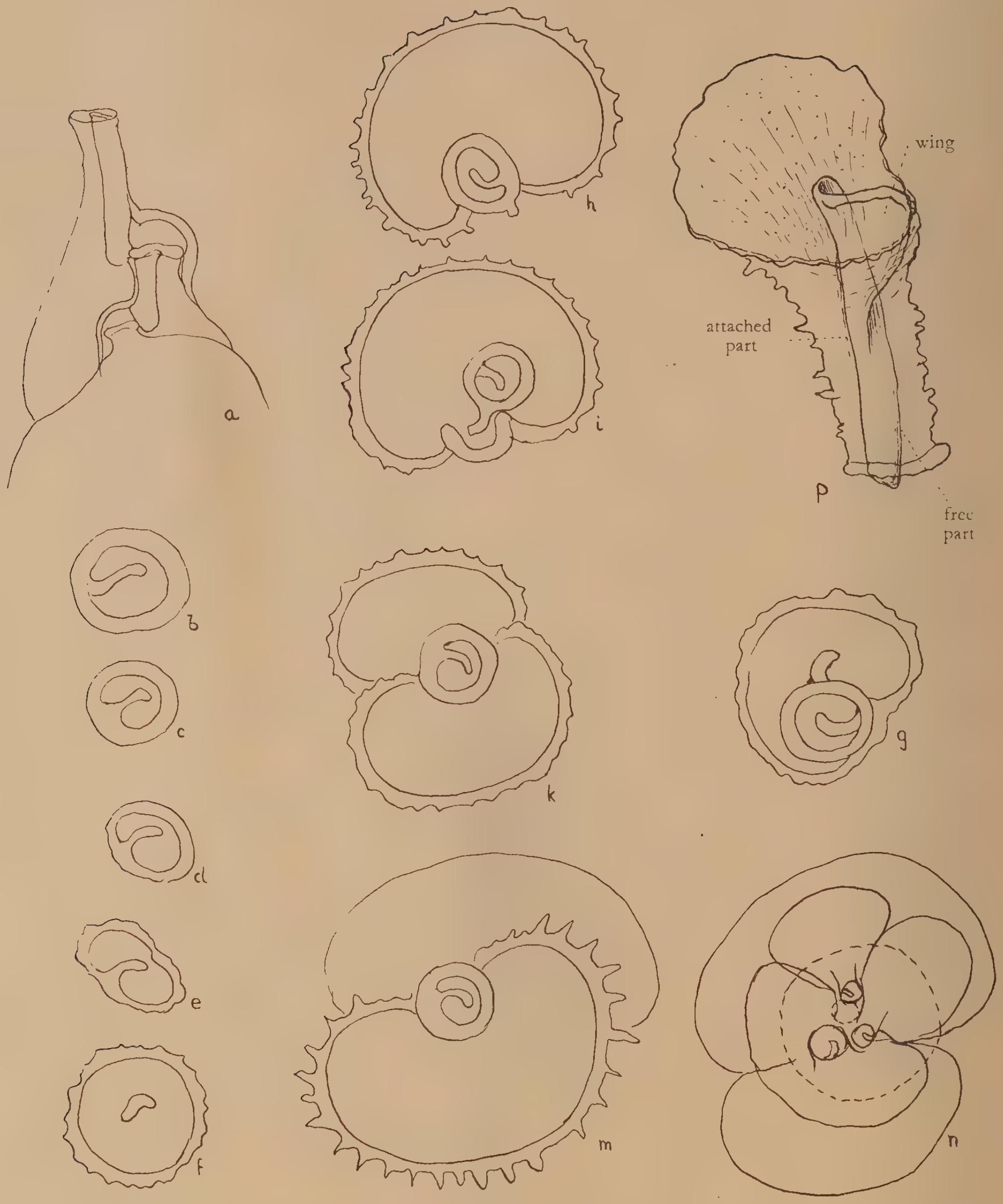


Fig. 138. *Neouvigerina ampullacea*. a, toothplates; b-g, successive sections through end-chamber; h, i, sections through second chamber; k, m, sections through biserial chambers; n, optical section through initial chambers, with biserial set, triserial set and proloculus, × 380; p, end-chamber of throughout triserial individual, loosened from test, showing a reduced wing, formed by the attached border of toothplate; seen from below; × 380.

Very typical specimens were found in many stations south of Sumatra (Mentawei-basin), and they were not so common in those around Flores. They occurred too at St. 266, 5° 56′ S., 132° 47′ E., depth 595 m.

In individuals with throughout triserial arrangement, the last-formed chamber, when loosened from the test, shows a toothplate which has formed a reduced wing at its base, attached to the outer (basal) wall, and running up unto the attached border of the toothplate in the neck. Here it is clearly shown, that there exists some relation between *Neouvigerina* and *Aluvigerina.*

Neouvigerina interrupta (Brady)
(Fig. 139)

This fine species occurred only at station 2° 34′ S., 99° 44′ E. depth 777 fathoms, in few specimens; a single specimen at 8° 15′ S., 118° 56′ E., 340 fathoms. It may be best distinguished from *Neouvigerina ampullacea* by the smaller size of the test, the more inflated chambers, the looser form of the whole shell. The lip of the neck of the aperture is very slightly developed, if at all, the spines are always very fine ones, often, especially in the B-generation, the later-formed chambers are formed like rain-drops, hanging on a central axis.

B-generation. 10 chambers, very loosely hanging together, diameter proloculus 8 μ. Length of shell 0,24 mm, breadth 0,08 mm. Young specimen.

A$_1$-generation. 12 chambers. Diameter proloculus 17 μ. Length of shell 0,27 mm, breadth 0,10 mm. The largest breadth about the middle of the shell.

A$_2$-generation. 7 chambers. Diameter of proloculus about 0,23 μ. Length of shell 0,27 mm, breadth 0,12 mm.

The species undoubtedly belongs to the group of the *Neouvigerinae.*

Toothplate very inconspicious and almost reduced, of the normal Neouvigerine type, without a prominent hook at its base, and the sides somewhat lobulated. The species is distinguished from real *N. ampullacea* more by its smallness than by the interrupted row of uniserial chambers, as in the A-forms this character is not very prominent. From *Aluvigerina indonesiae,* which is of the same size, it may be distinguished by the lack of ornamentation of *A. indonesiae*; the toothplates of these species also is differently shaped, as in *A. indonesiae* the base, on which the wing is situated is developed, while in *N. interrupta* it is totally absent and only the wing exists here.

Neouvigerina porrecta (Brady)
Figs. 140-142)

This small gracious species was a rare one at the stations south of Sumatra, except at station 2° 34′ S., 99° 44′ E., where it was rather common. I could study it in 32 specimens, two of them being microspheric, the other ones megalospheric. It was found too, but always rare, around Flores.

Statistic measurements made it clear, that the megalospheric specimens could be divided into two groups, the one with in the adult 13 chambers, the other with only 11-12 chambers. I will call these two groups A$_1$ and A$_2$, those with most chambers being A$_1$. They formed a single curve in respect to their diameter of proloculus.

B-generation. Two specimens. The proloculus had a diameter of 6 μ. Length 0,32 mm, breadth 0,06 mm. One specimen, moreover, had two apertures in the last-formed chamber, but with a toothplate projecting from the foramen of the former chamber. The protuberances on the surface were very irregular and on the last-formed chamber they were situated transversely to the length of the shell. The first part of the shell was somewhat curved. Total of chambers 17 and 16.

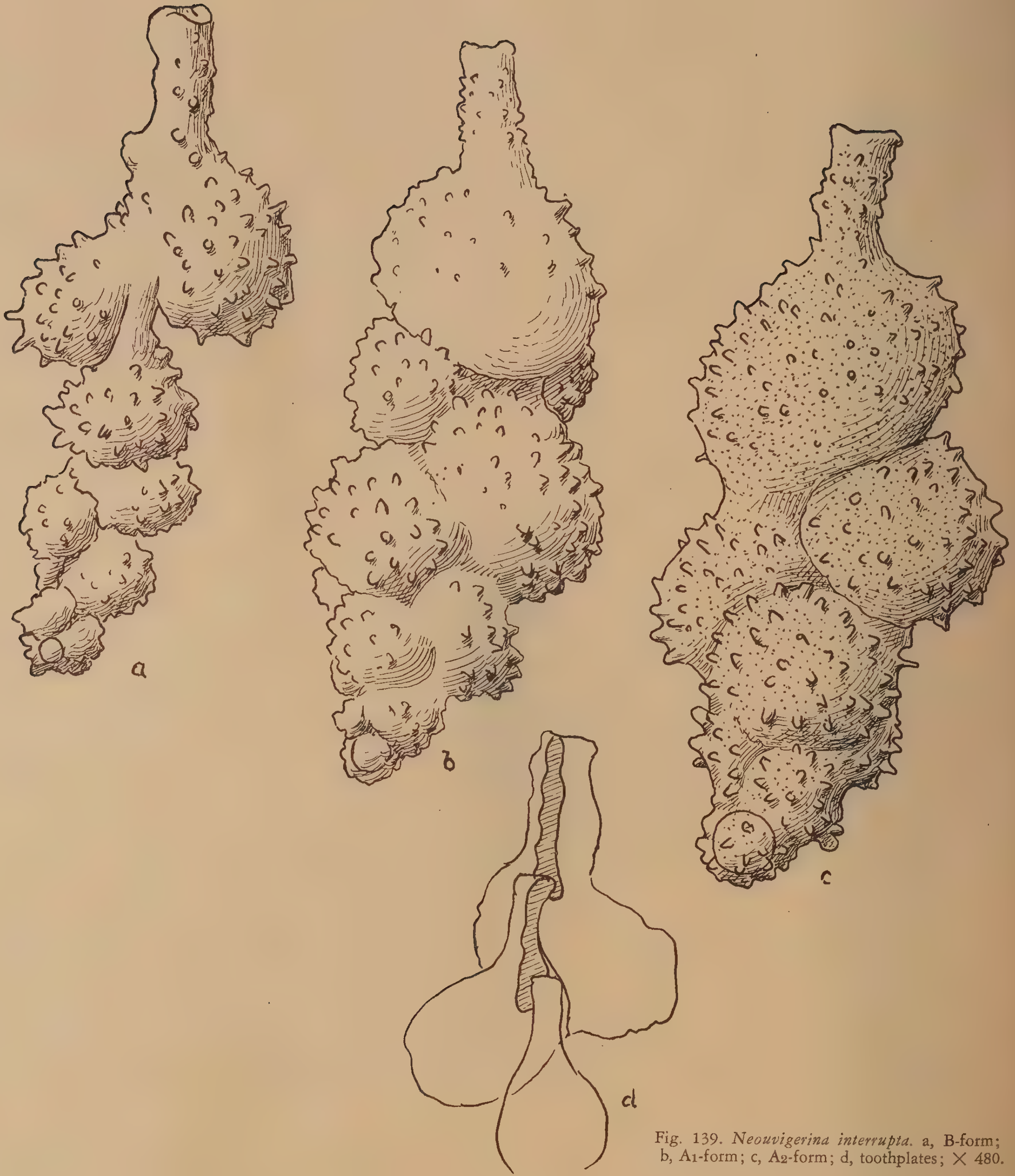


Fig. 139. *Neouvigerina interrupta.* a, B-form; b, A1-form; c, A2-form; d, toothplates; × 480.

A_1-generation. This generation was represented in the material by five specimens, three of them adult ones with the last two chambers uniserial and with a total of 13 chambers. In most of these individuals the protuberances on the surface were rather irregularly placed, only a few of them directed in the axis of the shell. The chambers are very inflated and the last-formed chamber always uniserially placed. Proloculus 11 μ in diameter. Length of the shells from 0,17 up to 0,25 mm, breadth from 0,08 up to 0,11 mm.

A_2-generation. This generation forms the main number of the individuals come to sight, viz. 24 of them. The total of the chambers is 11-12, while often only 10 or even 9 chambers occur. Very few of the individuals show a uniserial chamber at the end, most are triserially built throughout. The protuberances of chalk are more regularly arranged, most of them in the axis of the shell. The neck of the aperture is rather short, the whole test thicker and more bulky than in the two other generations, while the sutures of the chambers are less conspicuous. Proloculus from 13 up to 21 μ diameter, length of the whole shell from 0,17 up to 0,27 mm, breadth from 0,08 up to 0,12 mm.

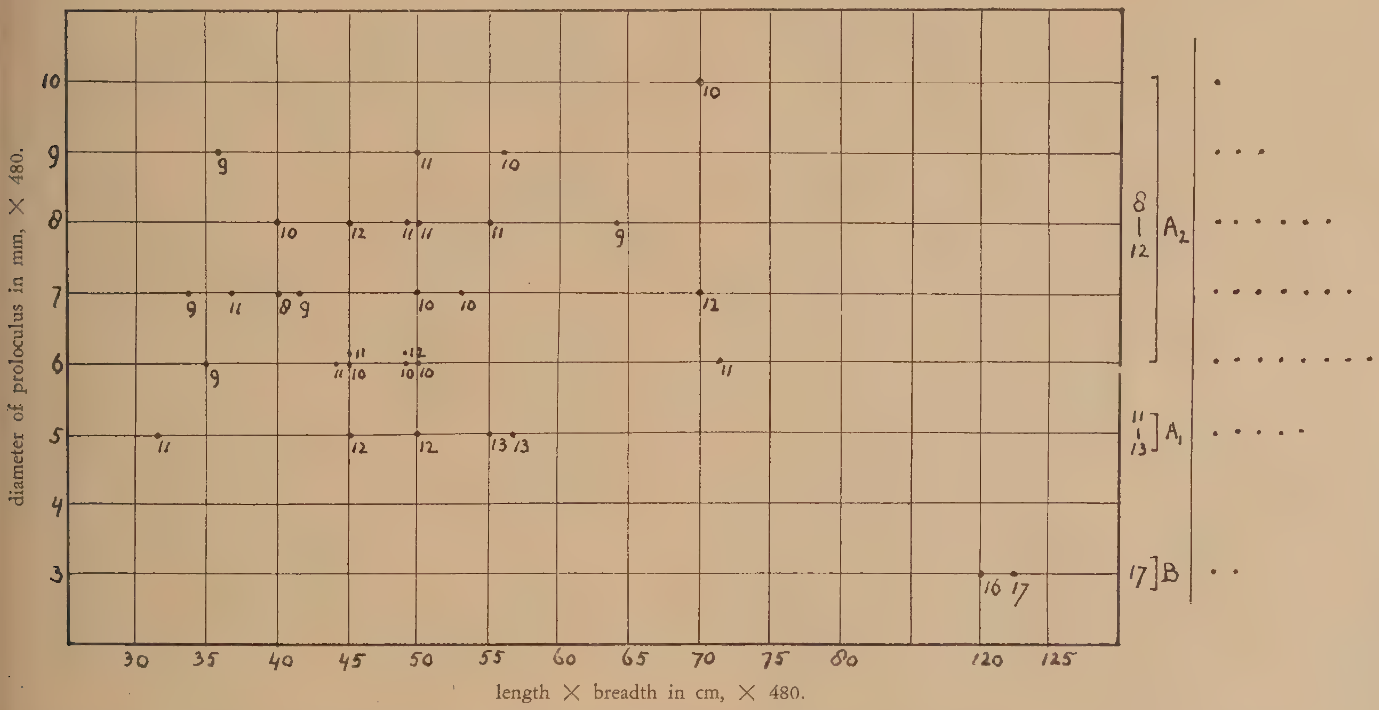


Fig. 140. *Neouvigerina porrecta.* Diagram showing relation between size of proloculus and product of length and breadth of tests. The number of chambers added, shows the difference between the three generations. Without that number one cannot distinguish the A-generations.

The toothplate forms a straight plate, beginning at the lip of the neck of the former chamber, and running straight on into the inner part of the neck of the aperture. This plate is narrow, and the tooth thus reaches only to the middle of the aperture. Most toothplates show a rounded hook at their beginning, and always they show an irregular free side.

When one neglects the typical outgrowths on the surface of the chamberwalls which replace the small spines of most other *Uvigerinae,* one comes to the conclusion, that this species must belong to that group of *Uvigerinae,* of which *Neouv. ampullacea* is the central form.

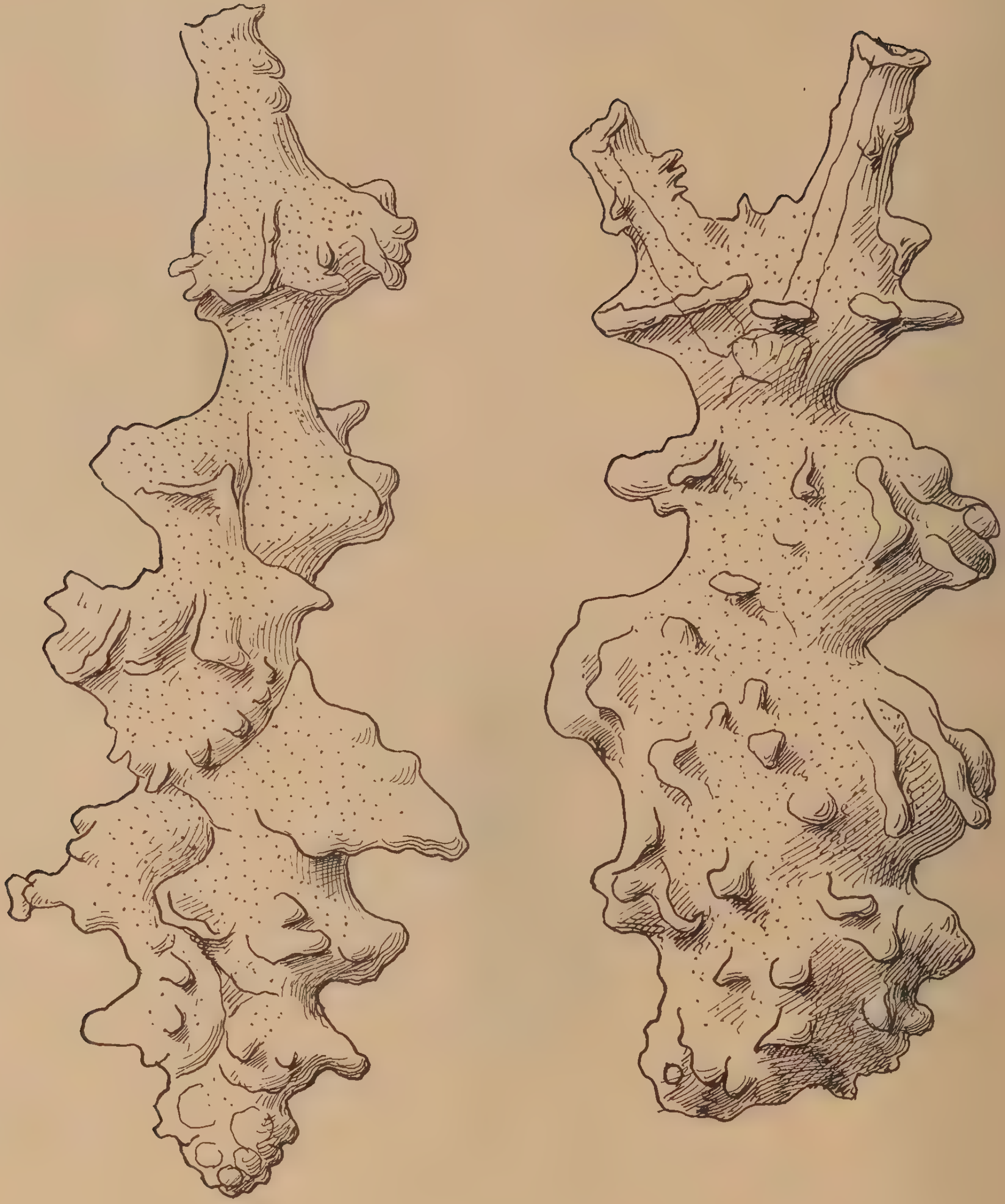


Fig. 141. *Neouvigerina porrecta.* Two microspheric individuals, one of which shows two apertures; × 480.

Genus **Euuvigerina**

This genus may have developed from *Praeuvigerina* by obliterating the folded part of the toothplate, so that only a more or less straight and simple plate remained, attaching itself with its whole broad base at the border of the former aperture. In most species of this group the surface of the shell is costate, and in most species the shellwalls are thick. Spines and costae may replace themselves in the different generations, and the apertural neck lacks pores totally.

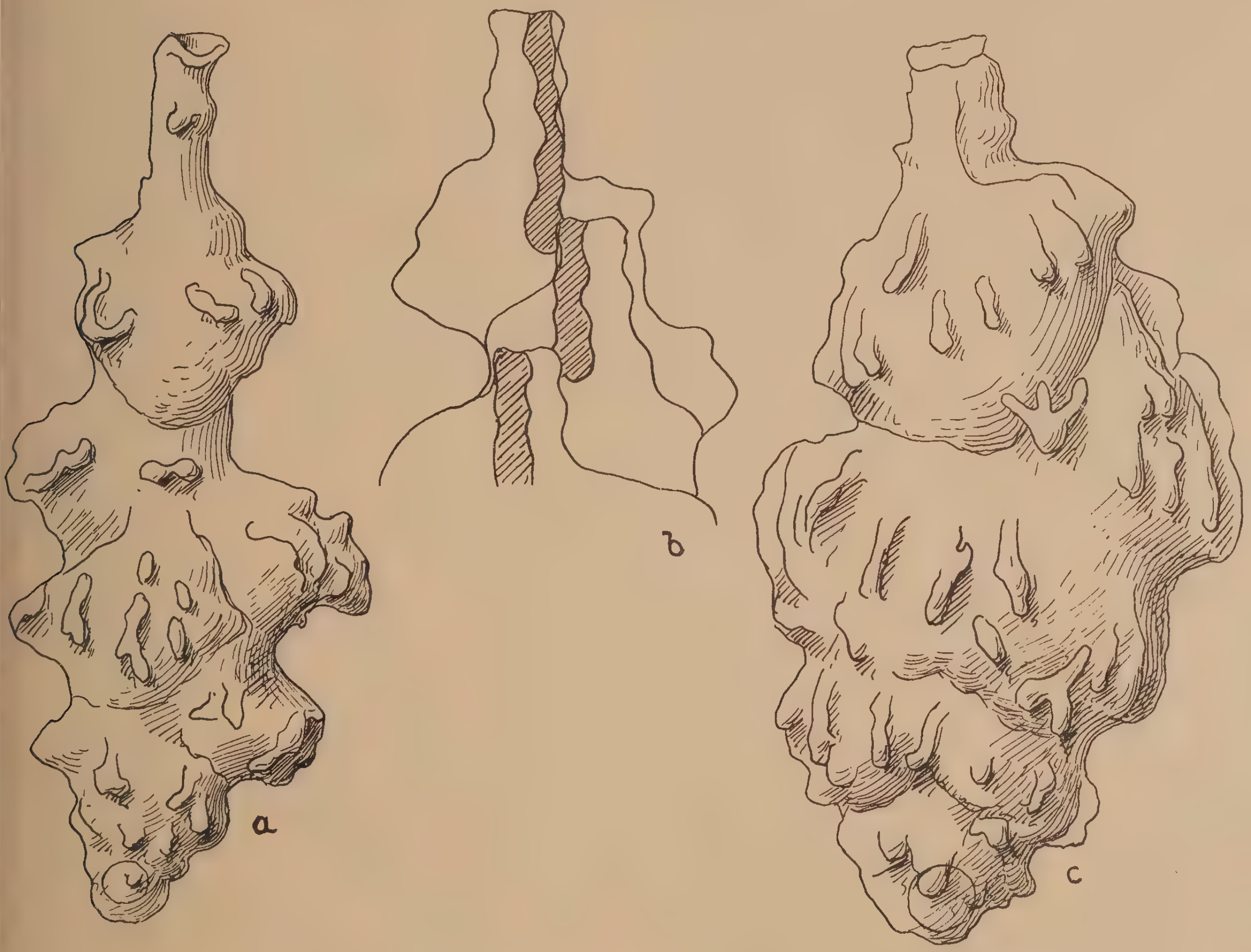


Fig. 142. *Neouvigerina porrecta.* a, A_1-specimen; b, toothplates; c, A_2-individual; × 480.

The genus occurs already in the Tertiary, but never in the Cretaceous, where it is replaced by its ancestor, *Praeuvigerina.*

Euuvigerina tenuistriata (Reuss)
(Fig. 143)

A single very typical specimen was found at St. 10° 00′ S., 123° 19′ E., depth 453 fathoms. Cushman mentions it (U.S. Nat. Mus., Bull. 100, p. 269) from Sibuko-Bay, Borneo, 310 fathoms and from Strait of Macassar, 272 fathoms. Millet did not record it from the Archipelago, so it seems to be very rare here. The specimen was megalospheric, probably A_1. The toothplate shows to be a thin plate, running straight from the border of the former foramen toward the side of the next, alternating with an angle of 120°. Its thinness, together with its very simple structure, without any folded side or wing, distinguishes it from that of *peregrina* and *aculeata*.

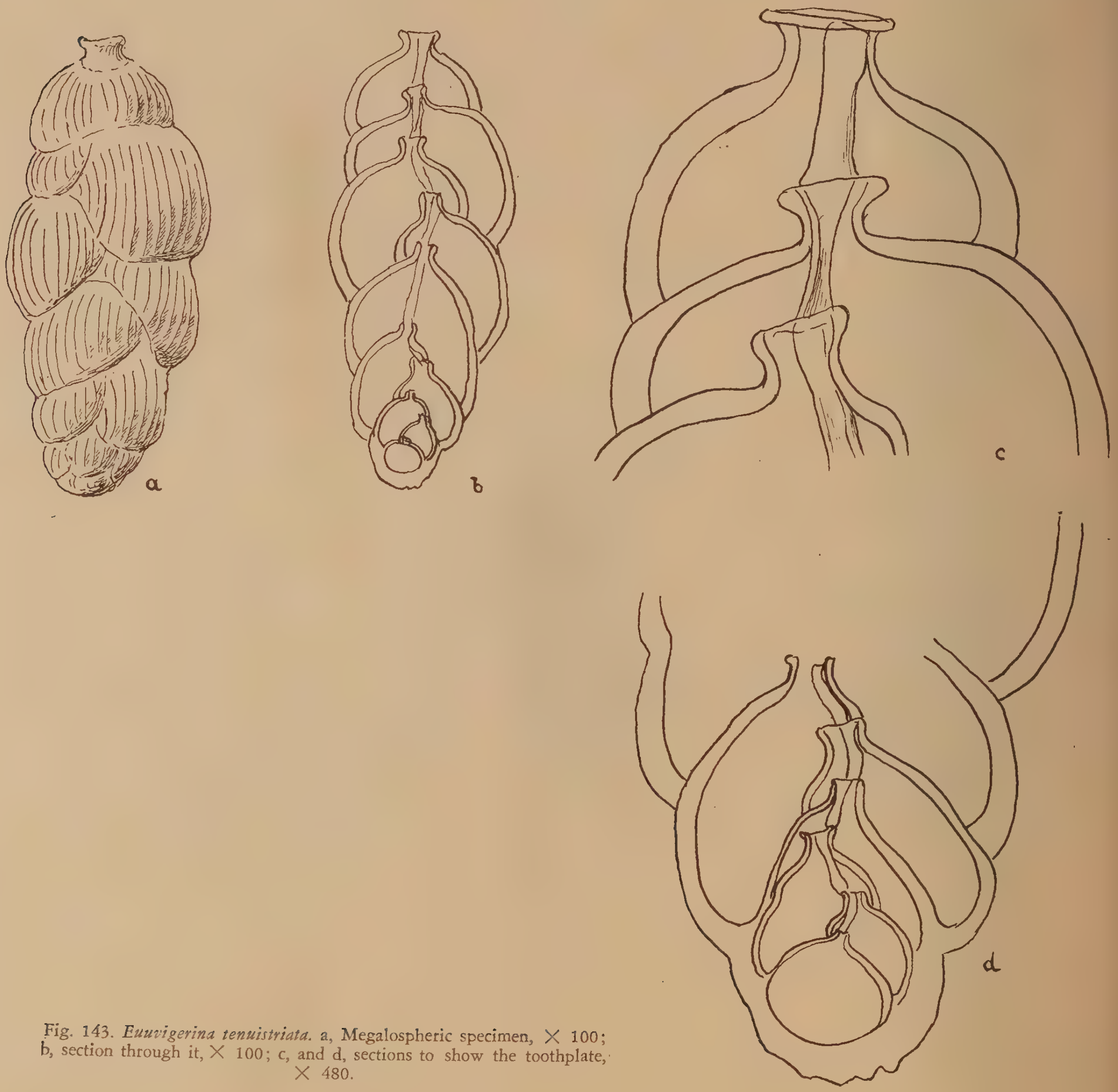


Fig. 143. *Euuvigerina tenuistriata.* a, Megalospheric specimen, × 100; b, section through it, × 100; c, and d, sections to show the toothplate, × 480.

Cushman's description runs (U.S. Nat. Mus., Bull. 71, pt. 3, 1913, p. 95): "Test elongate, subcylindrical, tapering at the apical end, composed of numerous rounded chambers with distinct sutures; wall with numerous fine raised longitudinal costae, except the distal portion of the last-formed chamber, or in full-grown specimens more than the last chamber, with roughened or even smooth walls, aperture with a short comparatively thick tubular neck with usually a distinct phyaline lip. Length about 1 mm."

Euuvigerina peregrina (Cushman)
(Figs. 144-149)

There seems to be some difficulty in the determination of this species, and several different species have been gathered in this specific name, all provided with longitudinal costae.

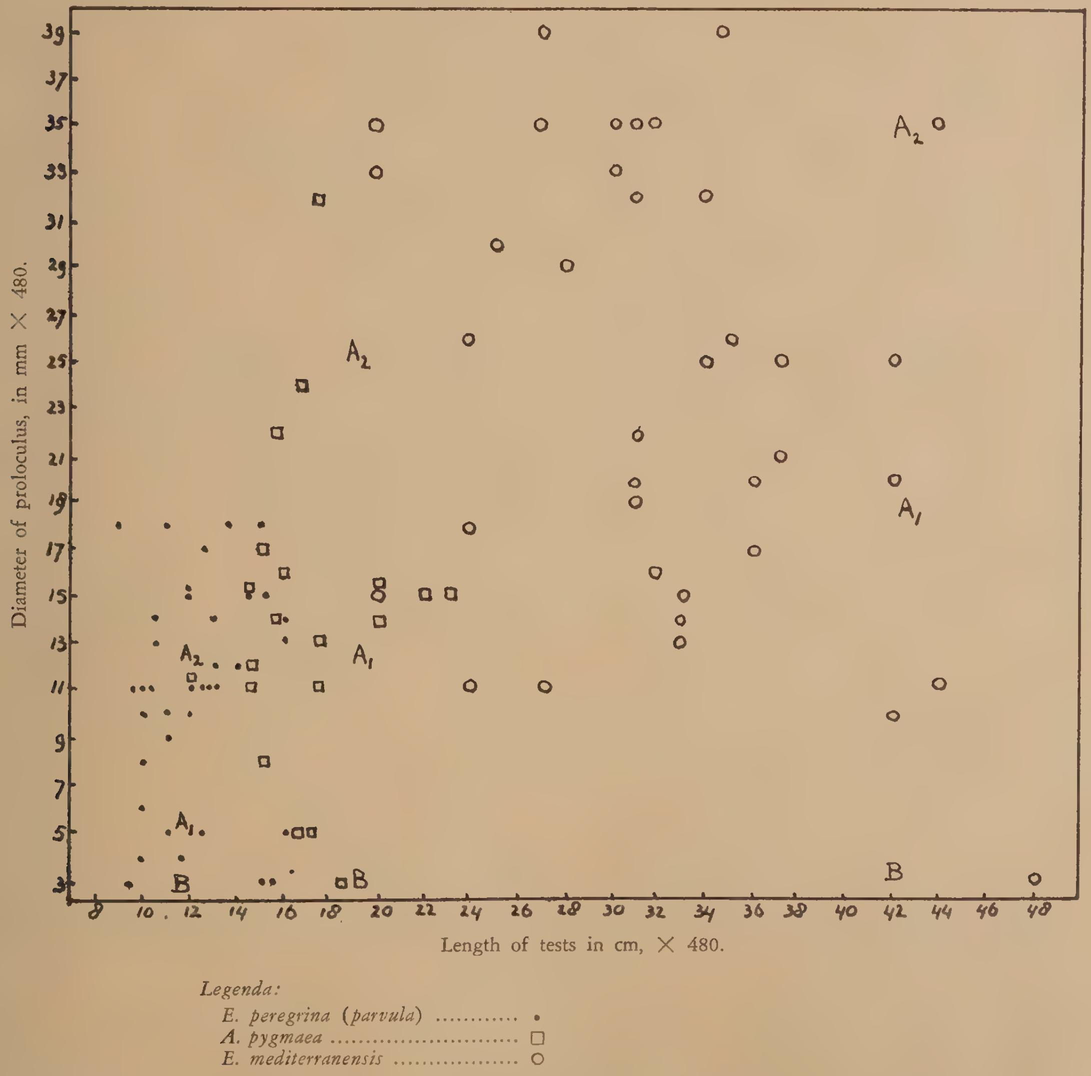


Fig. 144. Diagram showing, that the difference between three species, which are often entangled, may easily be detected by statistic analysis. Nor the length of shells, nor the corresponding size of proloculi, nor even the place of the three generations are identical. Yet in literature *mediterranensis* is identified with *peregrina*, and all three are often called *pygmaea*.

Cushman in his work on the Foraminifera of the Atlantic Ocean, created this new name to distinguish recent forms from tertiary *Uvigerina pygmaea,* from d'Orbigny. He gave moreover two varieties, *bradyana* and *parvula.*

I gave a new name to those specimens with longitudinal costae, found in my material from the Ammontatura near Naples in 1932 (Pubbl. Staz. di Napoli, Vol. 12, pt. 1, 1932, p. 118-120) and called this Mediterranean species *Uvigerina mediterranea.*

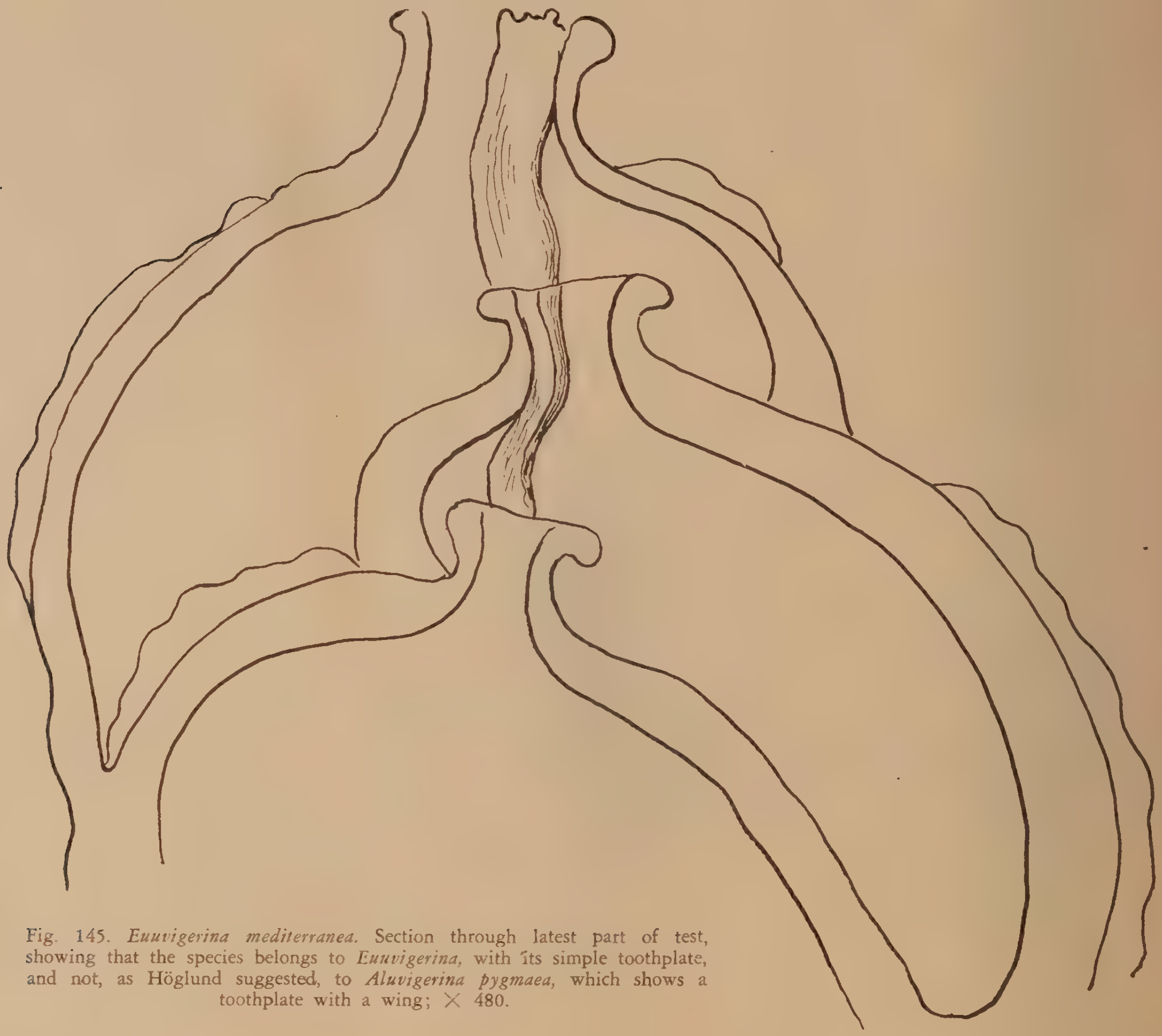


Fig. 145. *Euuvigerina mediterranea.* Section through latest part of test, showing that the species belongs to *Euuvigerina,* with its simple toothplate, and not, as Höglund suggested, to *Aluvigerina pygmaea,* which shows a toothplate with a wing; × 480.

In 1930 Cushman studied the species *U. pygmea* d'Orbigny (Contr. Lab. Foram. Res., Vol. 6, pt. 3) and came to the conclusion, that in *pygmea* the end-chambers are not costated and the costae are much finer than in the recent species.

In 1947 Höglund published a new record of a species, which he called *Uvigerina peregrina* (Foraminifera in the Gullmar fjord etc., Zool. bidrag fr. Uppsala, Vol. 26, 1947, p. 279-283). In this paper Höglund identified my species *mediterranensis* with his species, found in the North Sea, and says: "Hofker, 1932, p. 118, refers to Cushman's above mentioned work, but has evidently failed to observe the change of name as early as 1923, for he describes the form occurring in the Mediterranean as new under the designation of *U. mediterranea*." But he fails to prove, that my species is identical with Cushman's *peregrina,* which it is certainly not. Nor is his own material!

To entangle this question, I studied the following material:

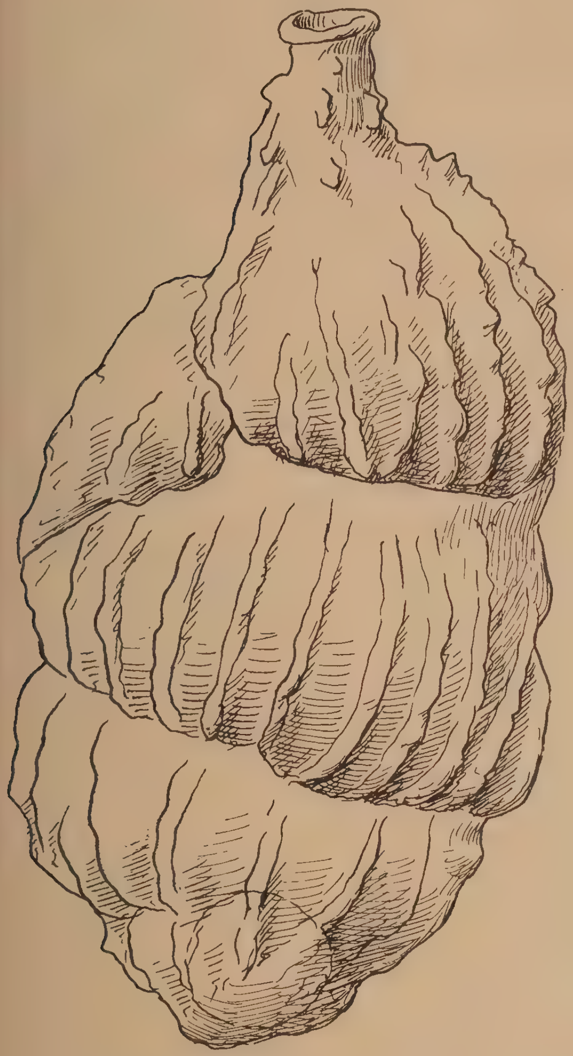


Fig. 146. ***Euuvigerina peregrina parvula,*** from the West-Indies. Megalospheric specimen, A_2; × 480.

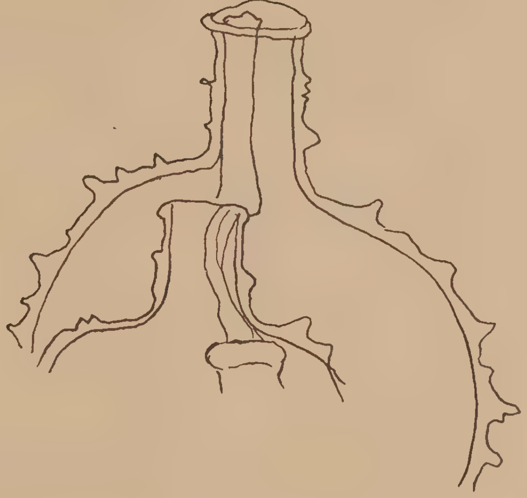


Fig. 147. ***Euuvigerina peregrina parvula,*** from the West-Indies. Section of apertural part of megalospheric specimen, with toothplates; × 480.

a. specimens from the Gulf of Mexico, in which Cushman found his variety *parvula,* which is without question identical with my material;

b. specimens from the Pacific, the East Indian Archipelago, from south of Sumatra as well as from the Savu-Sea;

c. specimens from the Ammontatura, gathered in 1930, but preserved until now;

d. specimens from Rimini, the place at which d'Orbigny collected, though *U. pygmea* came from Siena. (Described already here as *Aluvigerina pygmea*).

This material, together with the ample description Höglund's will reach to obtain sufficient knowledge of *U. peregrina,* described by Cushman.

His description (1923, p. 166) runs as follows:

"Test elongate, about 2½ times as long as broad, widest in the middle, ends rounded; chambers fairly numerous, inflated, distinct; sutures depressed but the line of the sutures indistinct; wall ornamented with longitudinal costae, about 10 on a full-grown chamber, those of each chamber usually not continuous with those of adjacent chambers, high and very thin and sharp, toward the base and apertural ends of the test becoming broken up into spines or irregular short portions; the wall between the costae and the costae themselves distinctly granular; aperture circular at the end of a distinct cylindrical neck, often spinose and with a phialine lip. Length up to 0,85 mm."

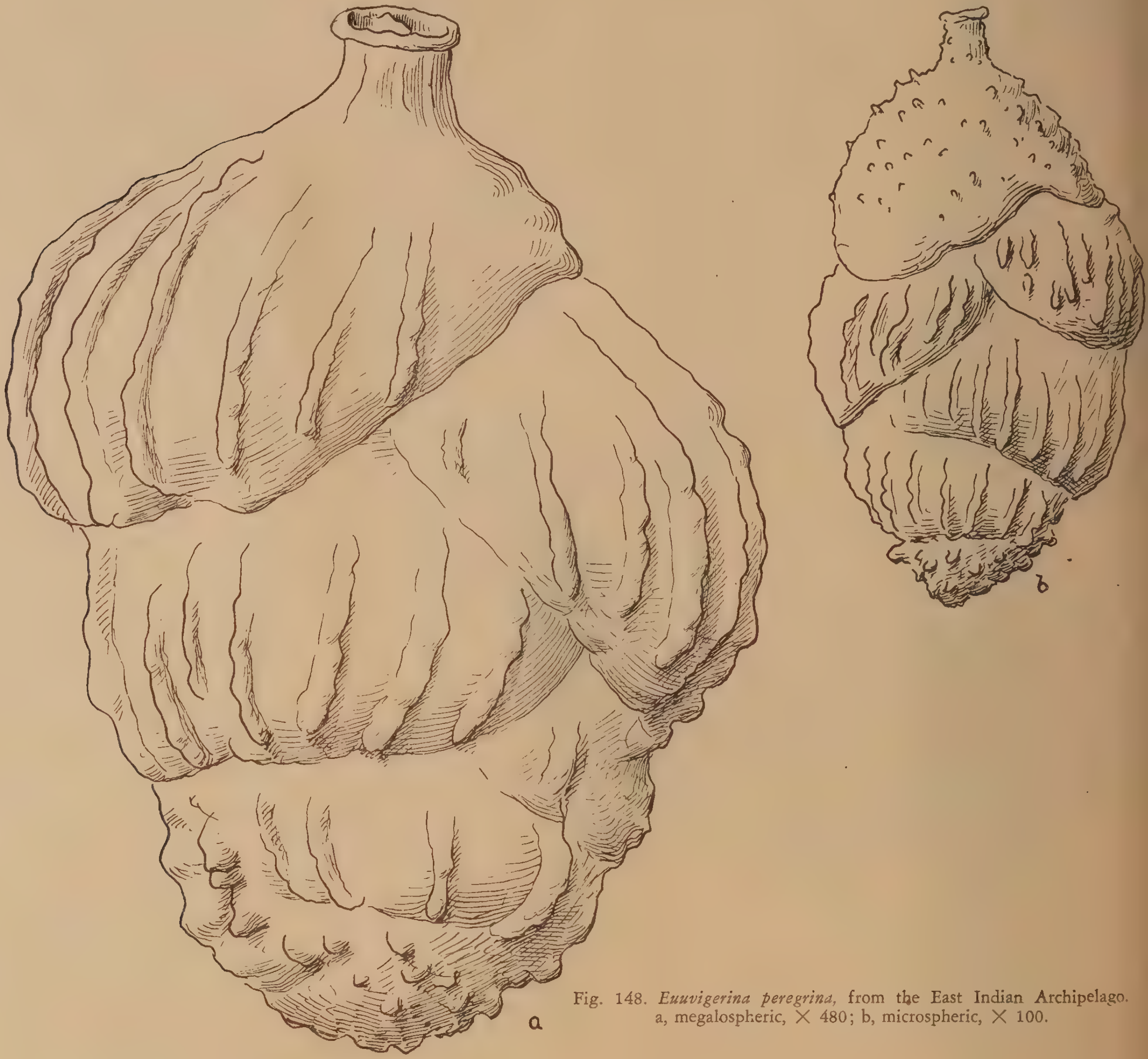


Fig. 148. *Euuvigerina peregrina,* from the East Indian Archipelago. a, megalospheric, × 480; b, microspheric, × 100.

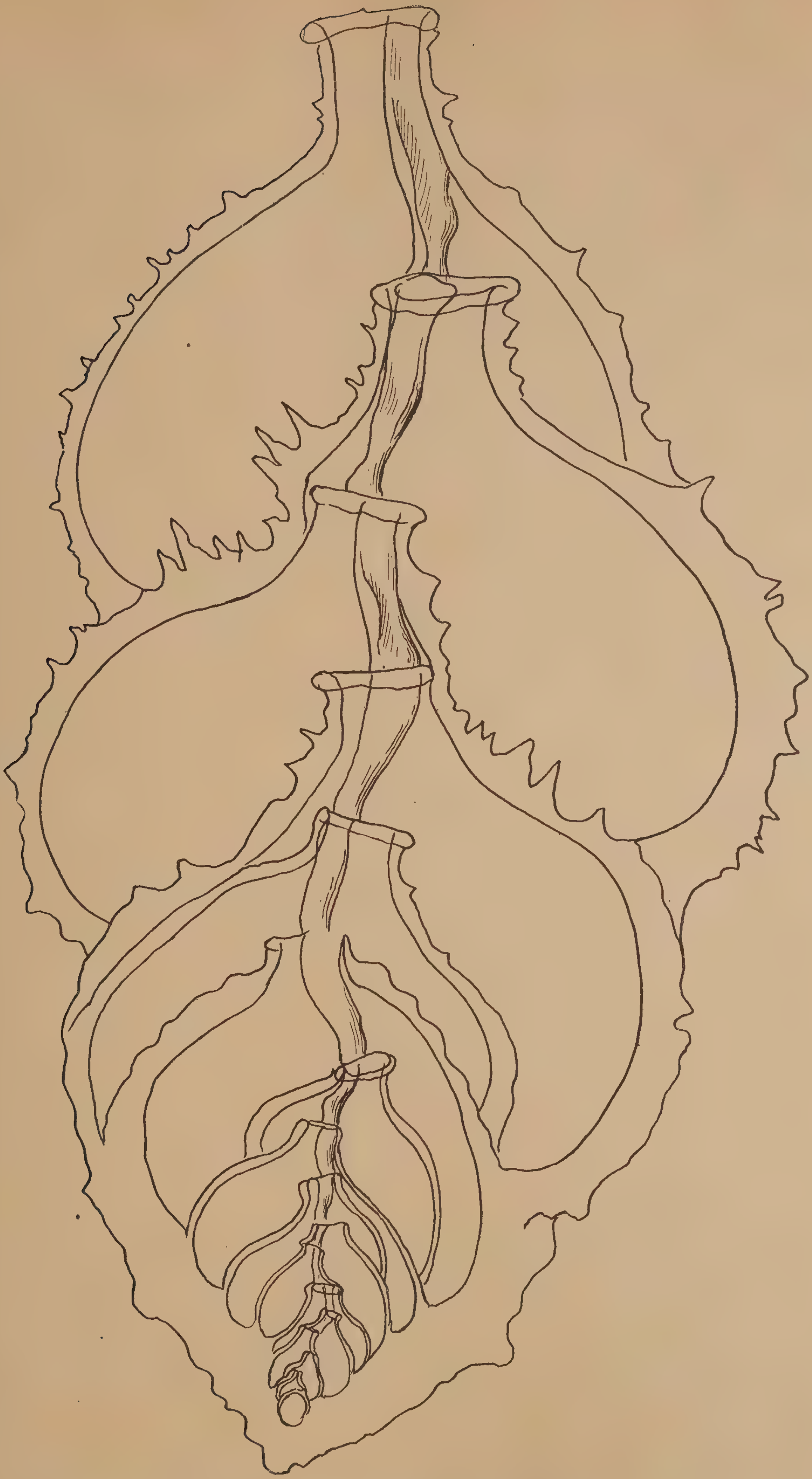


Fig. 149. *Euuvigerina peregrina,* from the East Indian Archipelago; section through microspheric specimen of Fig. 148 b, showing toothplates; × 420.

As Cushman points out, the species is distinguishable from *U. pygmea* by the thin, plate-like costae, the very granular surface, even of the costae, spinose and broken plates at the apertural and initial ends and the often spinose neck.

Uvigerina mediterranensis shows nothing of broken costae and granules, nor of spines on its neck, in none of the specimens. Höglund neither shows these characteristics in his many figures, dealing with the species. His figures and description of the outer characteristics agree in all details with those of my species *mediterranensis,* but the inner structure of the tests shows a striking difference. In the specimens from the North Sea, given by Höglund, the toothplate shows a "wing" at its dorsal part, whereas in my mediterranean species this wing is totally absent, and the toothplate is very much like that, found in *Uvigerina aculeata.* But, while in *aculeata* the spines often grow together to form costae, thus giving the character of *U. schwageri,* in *U. mediterranensis* no spines at all are present. So, I am quite certain, that Höglund's species from the North Sea is different from *U. peregrina* as well as from *U. mediterranensis.* Fossil specimens of typical *U. pygmea* however show the same wing on the toothplate, found in Höglund's material, so that I am positively inclined to determine Höglund's *U. peregrina* as true *U. pygmea,* so that Cushman's suggestion, that recent *Uvigerina* does not agree with the characters of *U. pygmea,* is not quite right, as the northern form seems to be the same as the fossil form from Siena [1]).

Uvigerina peregrina from the Carribean Sea shows all characteristics of those forms, found in the Pacific, and the latter specimens I found to possess all characteristics mentioned by Cushman for *U. peregrina,* but for its size, which is by all means smaller. The toothplates are quite similar, and the typical pointed granules on the surface, gradually coalescing in older chambers to form costae, are typical enough. Even the spinose neck is always present. This form, however, must be called *perigrina* by designation as well as by characters.

As for the Adriatic species, the length of the shell stands between that of *U. parvula* and typical *U. peregrina.* Here too the last-formed chambers, especially in the A_1-generation, show the spinous type, the neck often is provided with spines too, but a real phyaline lip nearly always is absent. The inner structure, however, is different from that of the forms just mentioned, as it shows a typical "wing" at the dorsal side of the toothplate. This must be called *Aluvigerina pygmaea,* the more, as the Siena-specimens are of some locality in the vicinity of Rimini, and from a not remote age; in the Gulf of Mexico many species are found living, which occur in the vicinity in tertiary strata as well. But here this Adriatic species shows in several forms fine granulations in the last chambers in the place of costae, thus pointing to *U. peregrina.* But the typical wing in the toothplate indicates without doubt, that this is a different species, compared with that, found in the Pacific and in the Caribbean region.

Our short analysis thus gives the following conclusions:

Two different species occur living, which are both closely allied to *Aluvigerina pygmaea* d'Orbigny, viz. one species described by Höglund as *U. peregrina* (wrongly), another found in the Adriatic near Rimini. Both show a wing at the dorsal side of the toothplate, but in the forms from the North Sea the costae are straight and never are replaced by spinous granulations. These granulations also are scarce in the Adriatic form. (I must point, however, to a mistake, made by Höglund, as he mentions the fact, that the microspheric specimens constitute 10 to 20% of the total number of the individuals, and then says, that the proloculi of these microspheric specimens measured from 13-19 μ in diameter; these measures are those of the A_1-generation, as a proloculus of the microspheric generation never measures more than 10 μ. In my Adriatic material a single microspheric specimen occurred with a proloculus of 6 μ). These two species may be varieties, due to different circumstances. So I will call both forms *Aluvigerina pygmaea.*

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[1]) Cushman points out (1930, see description of *Al. pygmaea*) that the Adriatic species only in minor characteristics is different from the fossil form.

In the Pacific true *Euuvigerina peregrina* occurs. This form must be closely allied to *Euuvigerina aculeata,* in which *U. schwageri* is only a generation.

In the region of the Gulf of Mexico a variety of *Euu. peregrina* is found, which, on first sight, may be identified with the form of *Alu. pygmaea,* found in the Adriatic, but which, on close examination of the inner structure, shows to belong to the *peregrina-aculeata*-group. This variety may be a constant species, *E. parvula.*

In the Mediterranean, at least in the Ammontatura, a form occurs which, with its thick walls and its typical toothplate, is very closely allied to *E. aculeata,* but for the fact, that the neck is always short and the costae are very regularly placed, without indication of spines whatever. It has been called by me in 1932 *Uvigerina mediterranensis,* and is in no way identical with Höglund's *U. peregrina,* now called *A. pygmaea.*

Once more we have come to the conclusion, that outer characteristics do not at all suffise to characterise a species of Foraminifera. Here only statistic measurements, together with the examination of the inner structure (toothplates) have given the characteristics to distinguish the different species of costate *Uvigerinae.*

I shall now try to give the characteristics, necessary to distinguish the species which have been discussed here.

Aluvigerina pygmaea. (See p. 203-205).

Costae fine, without granulations; neck with or without phyaline lip, often without; neck with fine granulations or with costae. At initial part costae often replaced by granulations. Toothplate with a dorsal wing. End-chambers often with granulations which replace costae. Length of Adriatic specimens in B 0,45 mm, in A_1 up to 0,35 mm, in A_2 up to 0,35 mm. In the North Sea-form the specimens are larger, as Höglund mentions for A_1 1,4 mm, for A_2 0,9 mm. The name, given by d'Orbigny however suggests a small species. (References and figures: Cushm. Lab. For. Res., Vol. 6, 1944, pt. 3, p. 62, pl. 9, fig. 14-20).

Euuvigerina peregrina.

Costae fine, and always granulate, replaced gradually in later chambers by granulations which at the neck of the aperture become fine spines. With phyaline lip. In some generations the chambers are all costate, in others they are more or less granulate, as in *E. aculeata.* Toothplate simple, somewhat folded, but never with a dorsal wing and without typical folded free part. In the pacific form the test reaches a length in agreement with the measures, given by Cushman, in the Caribbean Sea a smaller form occurs, which has been called by Cushman var. *parvula.* In this form the length of all generations is up to 0,33 mm.

Euuvigerina mediterranensis.

Costae not fine, but rather thick, and without any granulation on the costae. Endchambers often without costae, but these are never replaced by granules, and the wall then is smooth. Neck always very short, often costate too, with phyaline lip. Toothplate with irregular dentations at its upper end, curved, simple as in the *aculeata*-group, thick. Walls very thick, and at the initial end often with small spines, in which the costae end, especially in the A_2-generation. Length of B 1,1 mm, length of A_1 up to 1,0 mm, of A_2 up to 1,0 mm, but often shorter.

Euuvigerina aculeata.

Walls in the microspheric form with thick spines which often show the tendency to become short costae. In the megalospheric forms they form irregular costae or lengthened spines. Strong neck with phyaline lip, the neck often with finer costae. Toothplate very thick, folded somewhat at both sides, simple. End of toothplate smooth. Walls very thick. Length of microspheric tests up to 1,3 mm, of A_1 1,1 mm, of A_2 0,9 mm. *U. schwageri* is a synonym of this species.

In all these species the number of costae never can be used as a specific characteristic, as it is very variable in the different generations.

Euuvigerina tenuistriata.

Walls thin, with very numerous and fine costae, never with granules. Toothplate very simple, straight, thin. Neck stout with well-defined phyaline lip. Length of megalospheric specimen 0,75 mm.

Euuvigerina peregrina was found in several gatherings from the neighbourhood of Flores, always in scattered specimens.

Euuvigerina aculeata (d'Orbigny)

(Figs. 150-154)

Uvigerina aculeata d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 146, p. 191, p. 11, figs. 27, 28.; Cushman, J. A., U.S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 100, p. 43, fig. 4.

Uvigerina schwageri H. B. Brady, Rep. Voy. Challenger, Zool., Vol. 9, 1884, p. 573, pl. 74, figs. 8-10.; Cushman, U.S. Nat. Mus., Bull. 71, pt. 3, 1913, p. 97, pl. 37, figs. 3, 4.

I describe here *U. schwageri* as a synonym of *U. aculeata,* as these two forms occur in many stations together, and as they show the same inner characteristics, with their thick walls, the stout neck with its well distinguishable phyaline lip, the same stout typical toothplate, while types of *aculeata* always are microspheric, and those of typical *schwageri* always are megalospheric. Specimens with only costae which are running unbroken over the test, are of the A_2-generation, while those with costae, which are often broken off and in some cases resemble the spines, are of the A_1-generation. Typical spinous specimens are B-forms.

Todd, R., in: Cushman, J. A., and McCulloch, I., the species of *Bulimina* and related genera in the collections of the Allan Hancock Foundation, Vol. 6, No. 5, 1948, described *Uv. peregrina* var. *dirupta,* in which likewise specimens with costae occur together with totally spinous specimens.

The description of the two forms runs as follows:

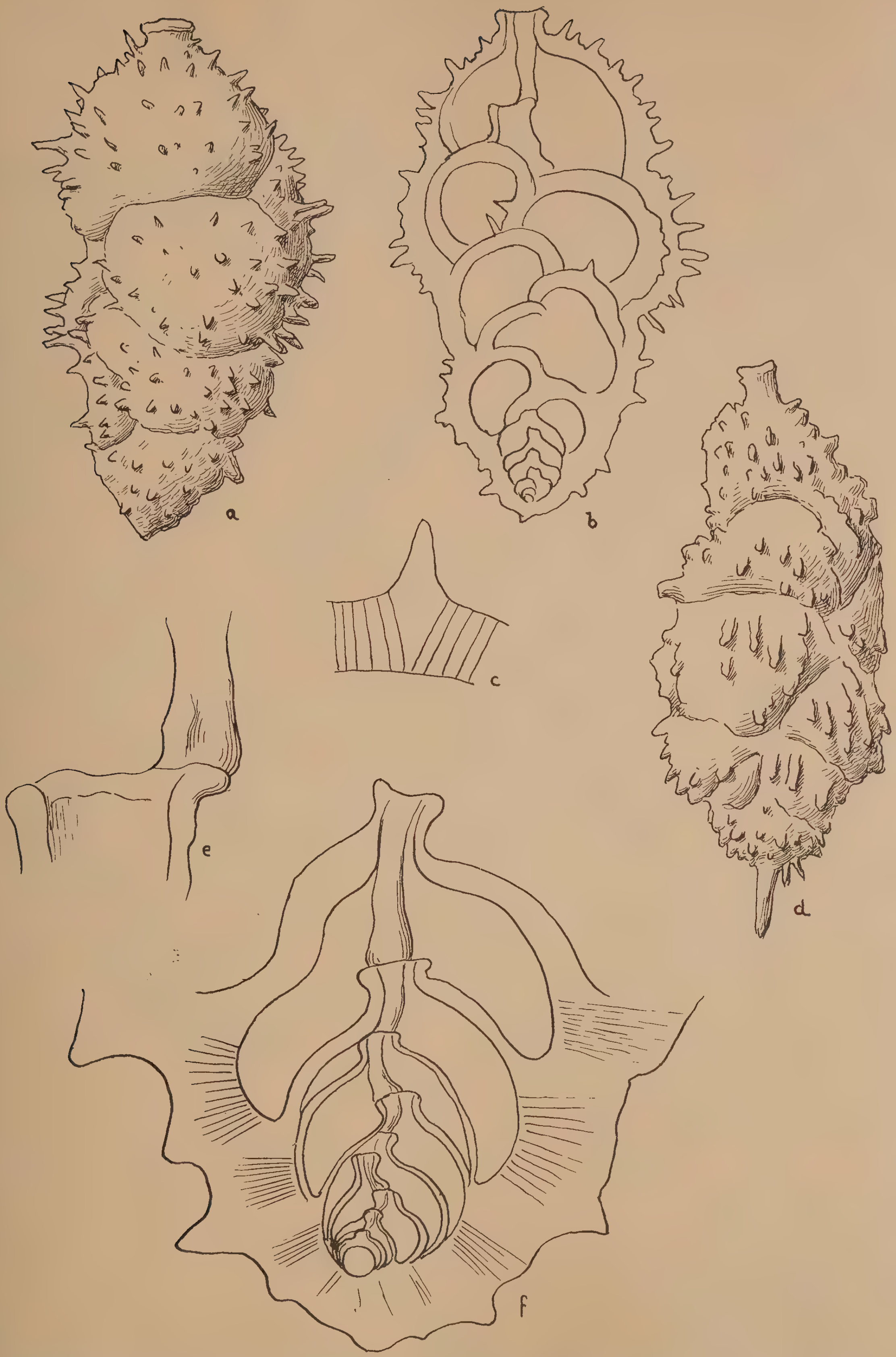


Fig. 150. *Euuvigerina aculeata.* a, microspheric, × 74; b, section, × 74; c, section through wall, with spine and pores, × 560; d, A_1-specimen, with apical spine; e, base of toothplate, × 430; f, initial part of microspheric specimen, × 430, showing the fine pores in the walls.

U. aculeata.	*U. Schwageri.*
Test elongate, tapering.	Test elongate, subovate, tapering to a blunt point at the aboral end.
Chambers numerous, inflated, sutures distinct, even under the ornamentation, which in the early chambers is often made up of longitudinal costae, the later chambers or all in some cases covered with a spinose development; the spines stout. Initial end of the test acute, usually with a spine.	Segments numerous, only slightly inflated externally, surface ornamented by a few ill-defined, partial costae.
Aperture with a short neck and flaring phialine lip.	
Length up to 1,5 mm.	Length 1,6 mm.

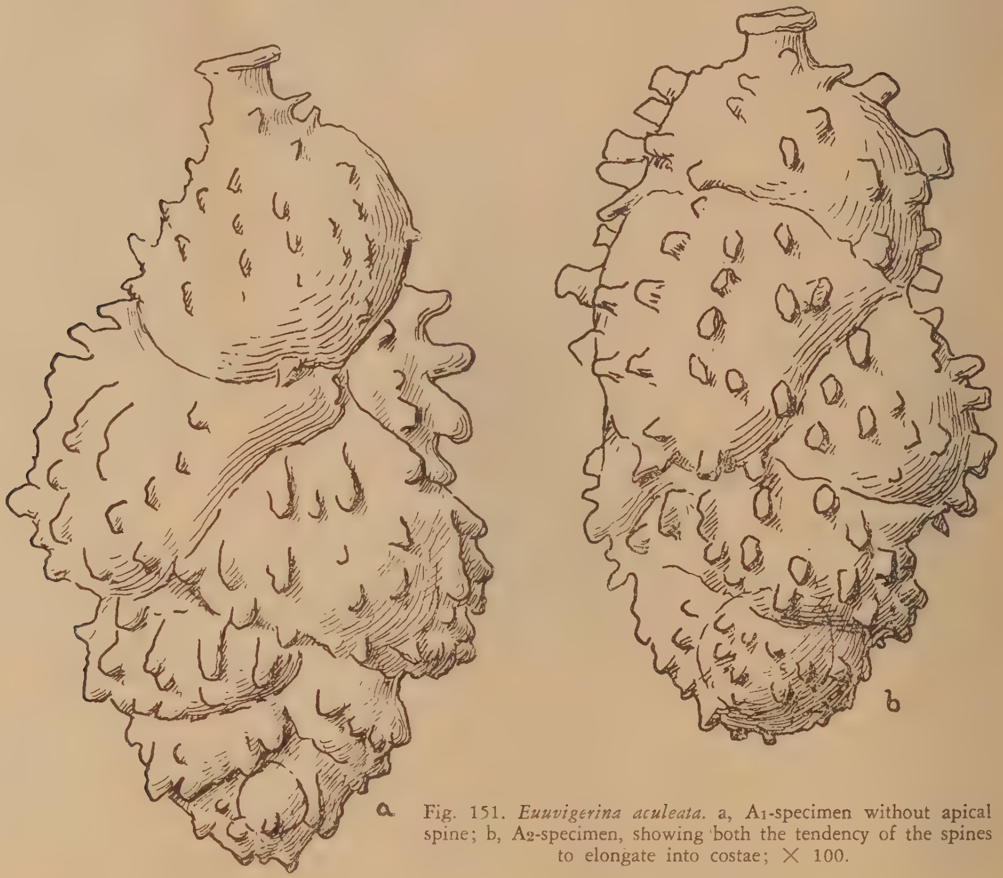


Fig. 151. *Euuvigerina aculeata.* a, A1-specimen without apical spine; b, A2-specimen, showing both the tendency of the spines to elongate into costae; × 100.

It may be, that some other species partly belong to this one, e.g. *U. striata.* There are all intermediate stages between typical *aculeata* and *schwageri.*

The most typical feature is the toothplate, as in all *Uvigerinae.* Here it begins at the border of the phyaline lip, fastened with the whole flat side of the plate, and smoothly detaching itself from the lip without any hook, running upward toward the next aperture, always somewhat twisted, thick and heavy. The sides of the plate too are smooth and rounded. It shows no "wing", as described

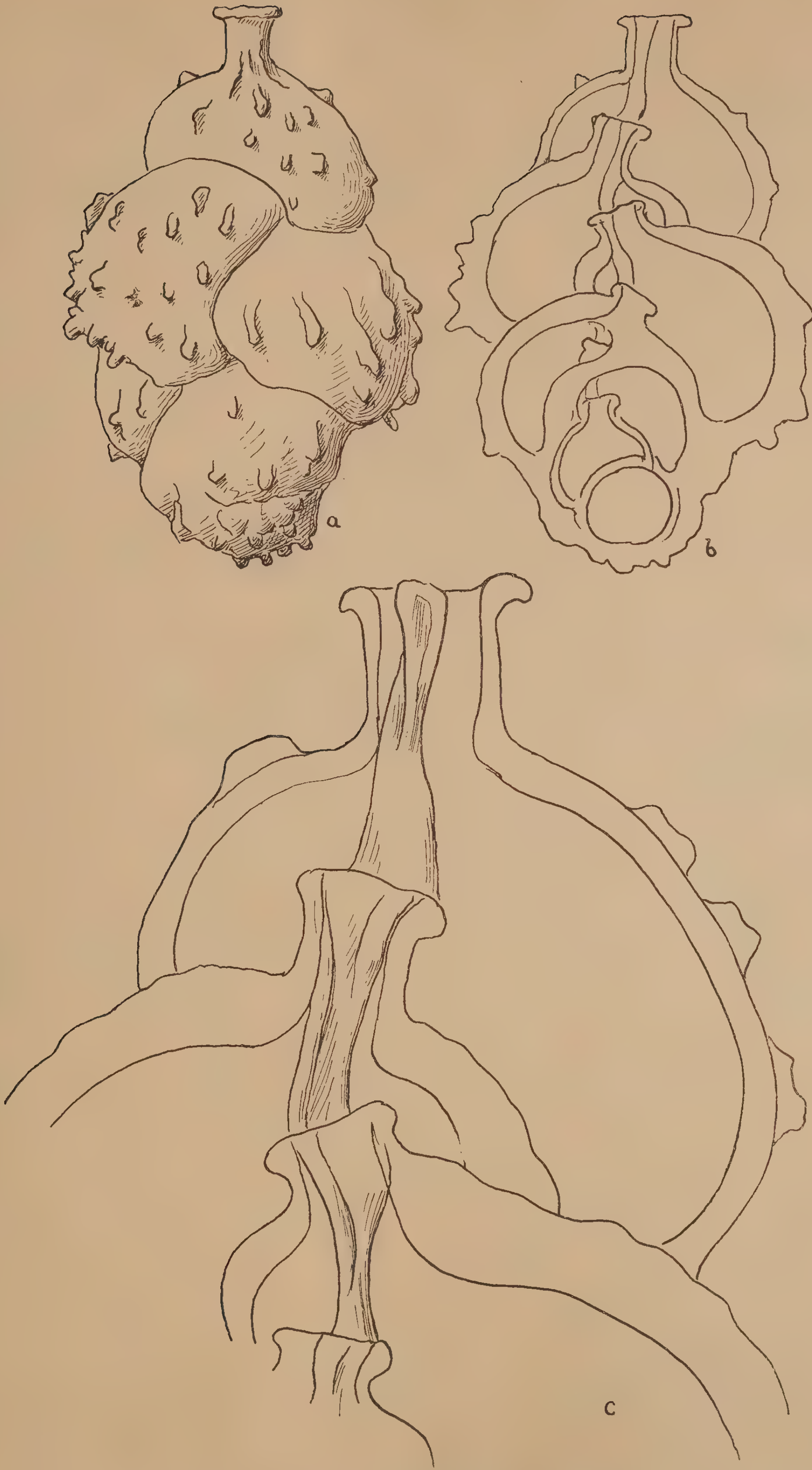


Fig. 152. *Euuvigerina aculeata.* a, A_2-specimen, × 90; b, section through it, × 90; c, section through apertural end, showing toothplates; × 430.

by Höglund for *A. pygmaea,* and in this way the latter species can easily be distinguished from *E. aculeata* or *schwageri.*

The proloculi of typical *schwageri* (A_2) have an inner diameter of 45-50 μ, those of forms, in which the ornamentation is irregular and the costae are partial, A_1, show a diameter of proloculus of 20-30 μ, while the microspheric specimens which have the habitus of *aculeata,* have a proloculus of only 10 μ. The latter forms show in the first-formed four sets of chambers very thin walls, except for the thickened outer walls.

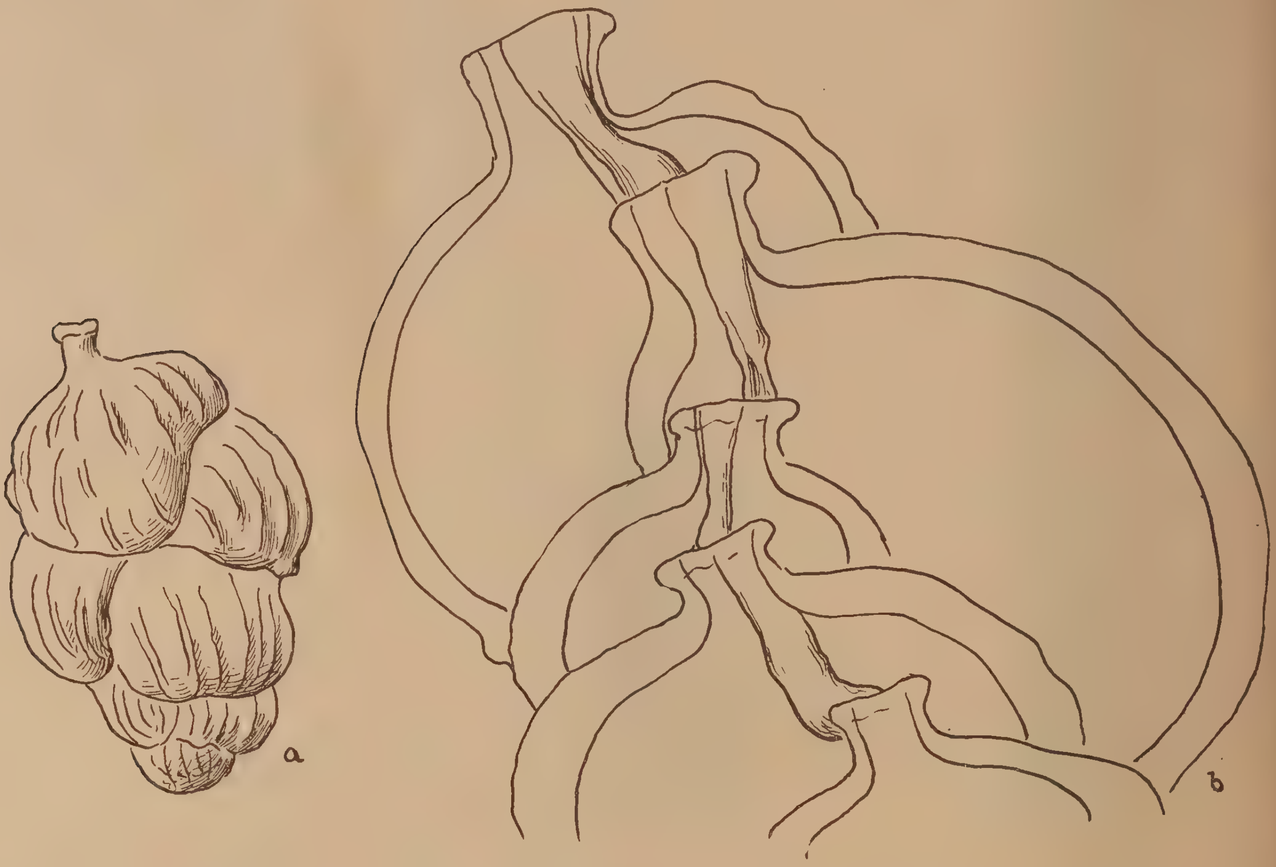


Fig. 153. *Euuvigerina aculeata.* A_2-specimen of the type, which has been known as *U. schwageri,* as the spines here are lengthened into real costae; × 80; b, section through same specimen, showing toothplates, × 480.

The species occurred at the following stations:
2° 56′ S., 99° 58′ E., 405 fathoms.
2° 17′ S., 99° 27′ E., 377 fathoms.
2° 2′ S., 99° 48′ E., 460 fathoms.
2° 6′ S., 99° 54′ E., 778 fathoms.

Yet megalospheric specimens in some cases show the characteristics of *E. aculeata,* when seen superficially; but a closer inspection reveals, that in those cases the ornamentation consists not of real spines, but of longitudinal series of very short costae which resemble spines but for their abrupt ending and their longer axis in the length of the test.

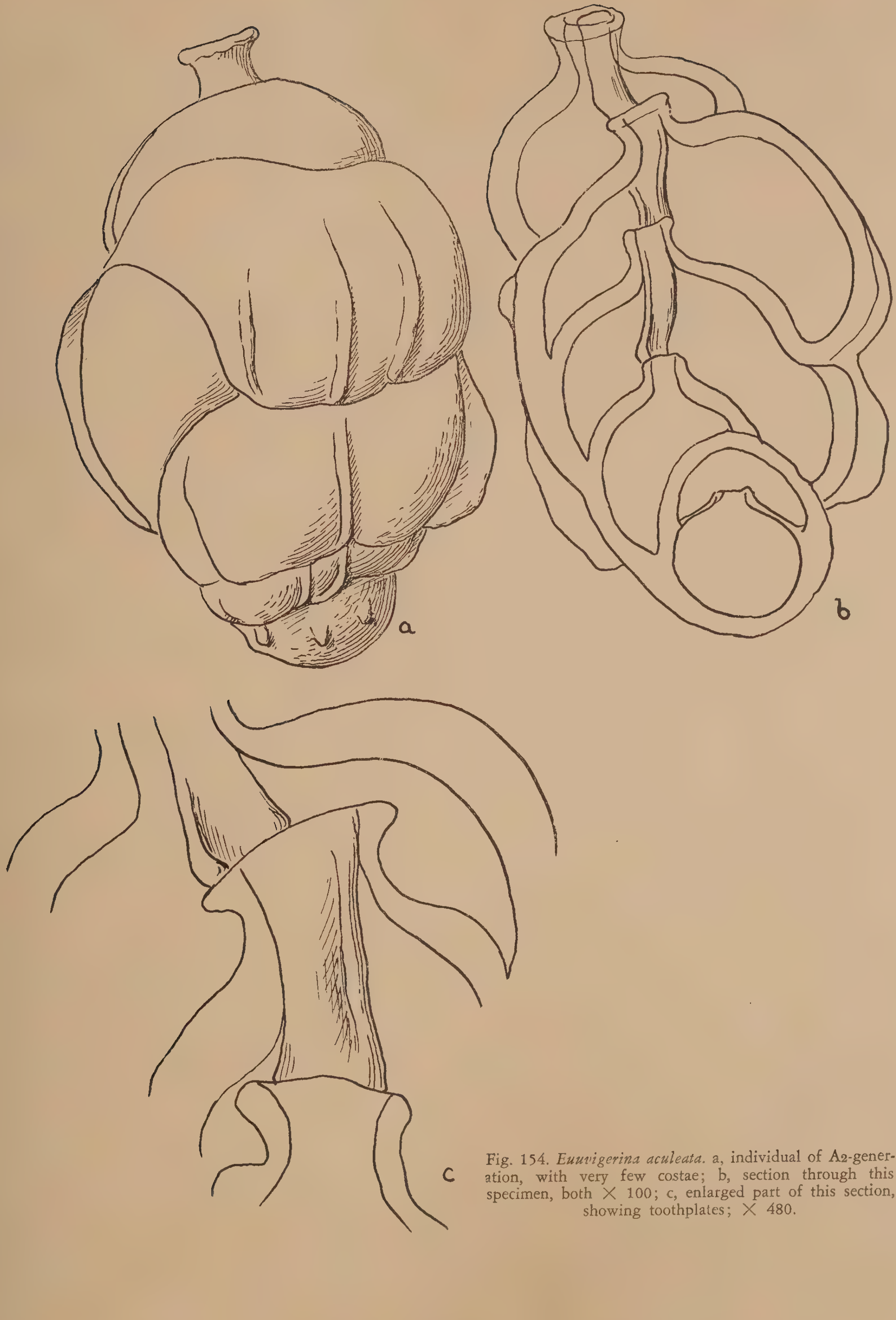


Fig. 154. *Euuvigerina aculeata.* a, individual of A2-generation, with very few costae; b, section through this specimen, both × 100; c, enlarged part of this section, showing toothplates; × 480.

Genus **Siphogeneria**

The genus *Siphogenerina* has been studied by Cushman (Proc. U.S. Nat. Mus., Vol. 67, Art. 25, 1926, p. 118). Later Matthews (Journ. of Paleont., Vol. 19, 1945, p. 588-606) tried to analyse the genus enew, but failed obviously, as he did not grant the toothplates their real importance. He created the new genus *Rectuvigerina,* stating, that several species belonging hitherto to *Siphogenerina* show in their early stages a triserial arrangement of the chambers, together with features of *Uvigerina.*

I here show, that most species of *Siphogenerina* are belonging to *Rectobolivina,* a single one to *Sagrina* as well. This entanglement was possible, since Cushman described the genus as follows:

"Test elongate, composed at least in the microspheric form of a series of chambers arranged *tri-* or *bi-*serially, followed by a later uniserial development; walls hyaline and perforate; aperture in the uniserial portion central and terminal, usually with an elongated neck and flaring lip; interior of the chamber with a tubular connection running from the base of the apertural neck to the lip of the aperture below; wall smooth or ornamentated by costae, pits, etc."

In this description species with a bi- and with a tri-serial arrangement are thrown together. This is due to the fact, that in typical *Siphogenerina* only in the microspheric generation the first chambers are arranged triserially, while in other generations they are bi- or even uniserially arranged in the beginning. But the danger was, that species, belonging to groups, which are biserially arranged throughout as is the case with *Rectobolivina,* could be arranged in this genus as well. So we have to correct this generic description now. Moreover it was shown, that there exists no "tubular connection" between the apertures, but a toothplate which never becomes tubular.

So the definition of *Siphogenerina* has to run as follows:

Test elongate, composed at least in the microspheric form of a series of chambers arranged triserially, followed by a later uniserial development; in the megalospheric forms a somewhat biserial arrangement may develop in the initial part. Walls hyaline and finely perforate; aperture in the uniserial portion central and terminal, with an elongated neck and flaring lip; always with a well-developed toothplate, simple with mostly slightly folded sides, running from one aperture to the next one. Wall ornamented by costae.

To this genus *Siphogenerina* which must be closely allied to the *Uvigerinae,* now belong only very few recent species, e.g. *S. raphana.* The genus must be linked to *Uvigerina* by those striate forms, known as *Euuvigerina,* as these forms show the same characteristics of the toothplate. It may be, that forms as *Siphogenerina irregularis* Cushman (Bull. 71, U.S. Nat. Mus., pt. 3, 1913, p. 109, pl. 47, figs. 6, 7) are the real links between the two genera. For in *S. irregularis* the uvigerine arrangement of chambers is quite well developed, and a closer examination may show, that this species in reality belongs to *Euuvigerina* as well.

The genus has developed in the Miocene, with forms as *S. lamellata* and *S. spinosa.* But the only species of recent age seems to be *S. raphana,* with some variations (*tropica*). All other species, arranged in this genus by Cushman, have shown to belong to other genera, mainly to *Rectobolivina,* as *S. columellaris, dimorpha, bifrons, virgula.* Even in the microspheric form they show a biserial arrangement. The aperture is here of no real generic value, as has been suggested, for an aperture with a neck has been developed in quite other genera, which show no relation whatever, such as *Siphonina* and *Clavulina.*

As there is no good in creating new genera, in the case older names can be used in a more strict significance, I did not follow Matthews in his creating a new genus *Rectuvigerina,* though in respect to the parallel genus *Rectobolivina,* it would be consequent. But I showed, that *Rectobolivina* is not a real genus, as very different groups of *Bolivina* may develop uniserial stages at the end. This may have ocurred also in the group of the *Uvigerinae,* and therefore there is no real necessity to create a new genus for those uniserial species allied with *Uvigerina* as well. So I maintained the genus *Siphogenerina.*

Siphogenerina raphana (Parker et Jones)
(Figs. 155, 156)

In the Archipelago the species is very rare, occurring only at the stations 10° S., 123° 19′ E. depth 453 and 8° 15′ S., 118° 56′ E., 340 fathoms, and only in few specimens. Hence it does not occur in the western part of the Archipelago. It is mentioned by Cushman (Bull. 100, U.S. Nat. Mus., 1921, p. 281) from 8° N. to 2° S., and from 118° to 123° E., thus North to Celebes. While in the Philippines it is rather common, south to it it becomes very rare. Yet I was able to trace several megalospheric and a single microspheric specimen.

B-specimen. Length 0,35 mm, breadth 0,18 mm. The proloculus measures 10 μ diameter, followed by three chambers arranged triserially. Then 11 uniserial chambers are added, the last-formed of which shows no ornamentation. This ornamentation consists in the later chambers in longitudinal costae which are prolonged over the former chambers. The sutures between the chambers are very low, and are only visible by their lacking pores. The pores are rather fine. In the initial part of the test, however, the costae become flattened and broadened at their outer part, thus giving rise to a kind of chamberlets, situated outwardly from the porous walls, and running down between the costae. Their outer walls have no pores, but are very hyaline. The aperture is somewhat oval.

A_1-specimina. They all show an initial chamber of about 20 μ diameter, followed by a second chamber, which is situated beside the proloculus, and is nearly equal of size. Then 8 chambers are added which are uniserial. The last-formed chamber lacks the ornamentation. Length 0,21 mm, breadth 0,10 mm.

A_2-specimen. Only a single large proloculus forms the initial end, measuring about 30 μ diameter. It is followed by 7 uniserial chambers, the last formed one lacking ornamentation.

Each foramen of the uniserial chambers is attached to that of the next one by a very thick toothplate, attached with its whole base at the phyaline lip of the former aperture, then curling round, so that its hollow side at its end runs in the direction opposite to that of its base. The successive toothplates form an angle of 120° with the former one, thus indicating strongly, that this species does not belong to the group of *Rectobolivina,* as the other species, hitherto arranged in the genus *Siphogenerina,* do. Thus it is clear, that the species is closely allied to *Uvigerina,* with its neck and phyaline lip. Matthews has proposed new names for those forms, but, as he has not studied the toothplates, it is obvious, that very different species belong to his new genera. Thus I propose to use the older name of *Siphogenerina,* but with the restriction, that only those forms with phyaline lips, beginning in the microspheric forms with a triserial arrangement and with the toothplates directed in angles of 120°, are real *Siphogenerina.* This is possible, as in the definition of *Siphogenerina* Cushman gathered species with bi- or triserial arrangement of chambers in the initial part. This remains true for the A_1-generation, which begins biserially.

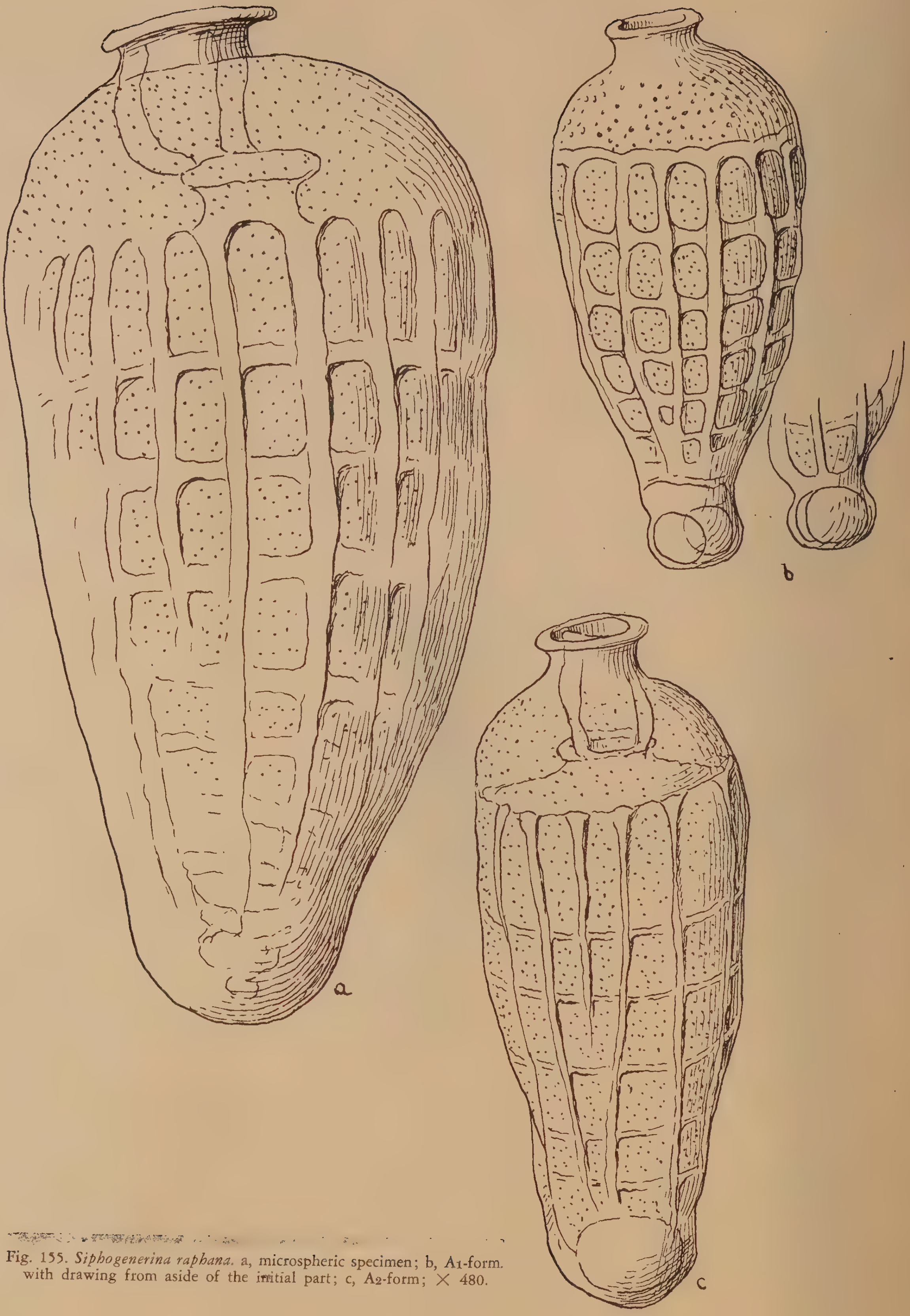


Fig. 155. *Siphogenerina raphana.* a, microspheric specimen; b, A1-form. with drawing from aside of the initial part; c, A2-form; × 480.

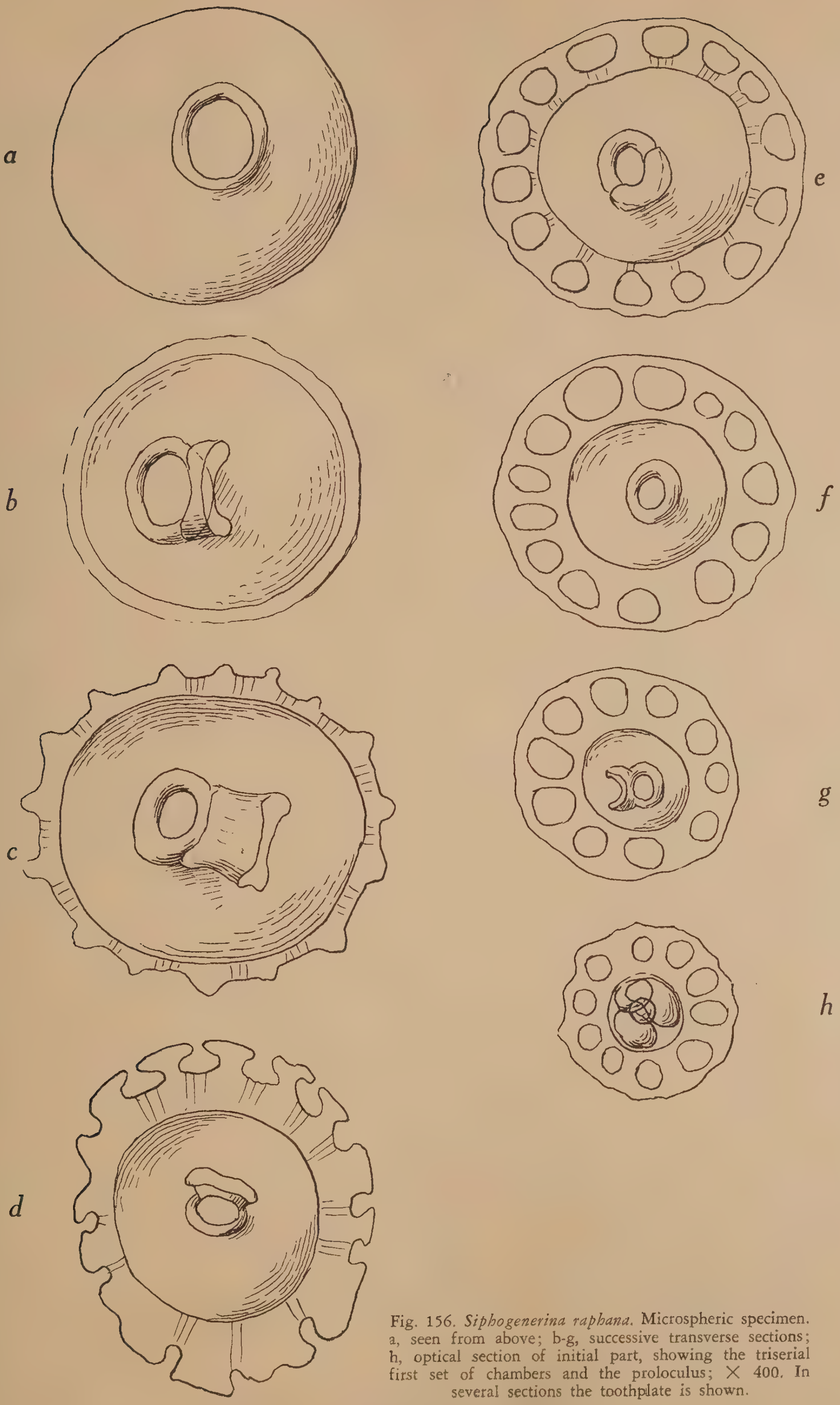


Fig. 156. *Siphogenerina raphana.* Microspheric specimen. a, seen from above; b-g, successive transverse sections; h, optical section of initial part, showing the triserial first set of chambers and the proloculus; × 400. In several sections the toothplate is shown.

Family *Virgulinidae*

This family, with only one genus, *Virgulina,* always shows a very hyaline test, with thin walls, very fine pores, a loop-shaped aperture with a toothplate which is attached to one border of the aperture, and with a folded free part, ending mostly in a more or less sawed tooth. The shell always shows in its initial part a triserial arrangement of the chambers which may become later on biserial or even irregular, with twisting of the plane of the chambers. It is not sure, in which geological time the family of the *Virgulinidae* started, as many species which were called *Virgulina,* showed to belong to quite other groups, as *Cassidella.* In the description by d'Orbigny about this genus, he stresses on the hyaline test: "Coquilles d'une texture vitreuse, très translucide". The type, however, *V. squamosa* d'Orbigny, 1826, does not correspond with that description, as the test of it is not translucent and very hyaline, but opaque.

Real *Virgulina* has already been found in the Lower Cretaceous; it is *Virgulina primitiva* Cushman. A comparison of the original figures showed me, that real *Virgulinae* are: *Virgulina recta* Cushman (Upper Eocene); *V. reussii* Geinitz, Cretaceous; *Virg. schreibersiana* var. *complanata* Egger, recent, Australia; *V. schreibersiana* var. *spinosa* Heron Allen et Earland, recent, Falklands; *V. seminuda* Natland, recent, California; *V. squamosa* var. *striata* Bagg, recent, Hawayan.

As I shall show here, the genus *Globobulimina,* hitherto believed to belong to the *Buliminidae,* is better placed among the *Virgulinidae.* As in *Virgulina,* the beginning of the tests of *Globobulimina* is triserial, ending however biserially throughout. As in *Virgulina,* the test is thin and hyaline, and the pores always small and covering the whole wall of a chamber except for a part, bordering the aperture. As in several species of *Virgulina* (*V. subdepressa, V. pauciloculata*) the first chamber of megalospheric forms is very large, tending to become egg shaped. As in *Virgulina* the toothplate is of a peculiar shape, the attached border often becoming protruding, the free part always simple, and the whole structure of the plate simple also; the attached part in *Virgulina* forms a large part of the inner wall of the aperture, and in the genus *Protoglobobulimina* this is likewise the case. As in several genera of *Virgulina* (*V. schreibersiana*), spines are developed at the apical end in several primitive species of *Protoglobobulimina.* The only real difference between *Virgulina* and *Globobulimina* is found in the shape of the larger pores, being elongate at the surface of the wall, as Höglund showed first, in *Globobulimina.*

A comparison of the toothplates of *Bulimina* and of *Globobulimina* shows furthermore, that in the latter genus the toothplate cannot have derived from that of *Bulimina.* I have shown, when dealing with *Bulimina,* that in most species the toothplate of that genus is of a rather complicated structure. The toothplate of *Globobulimina* on the other hand is quite simple, being a building like a cornet, and not possessing any trace of a second foramen.

Typical *Globobuliminae* occur already in the Miocene, as I found, when studying samples of typical Miocene formation from Holland; they show the typical toothplate of *Globobulimina,* together with the elongated pores.

All these facts lead to the conclusion, that *Protoglobobulimina* derived from *Virgulina,* and that afterwards the genus *Globobulimina* was developed, by forming a toothplate, more adaptated to pelagic life, with its typical fan-shaped tooth. This adaptation may lie in a floating protoplasm net, which may be adjusted at the fan of the toothplate.

I am convinced, that *Protoglobobulimina* is an offspring from a species, closely allied to

Virgulina schreibersiana, as the toothplates of both show the same peculiarities, with its protruding attached part. Moreover, larger specimens of *V. schreibersiana* show already inflated and overlapping chambers. In *Protoglobobulimina* and in *Globobulimina* this overlapping of chambers becomes more prominent. In another paper I shall deal more exhaustively with this question.

Genus **Virgulina**

There exists much confusion in this genus, as very different species, often generations of other genera, have been regarded as belonging to this genus.

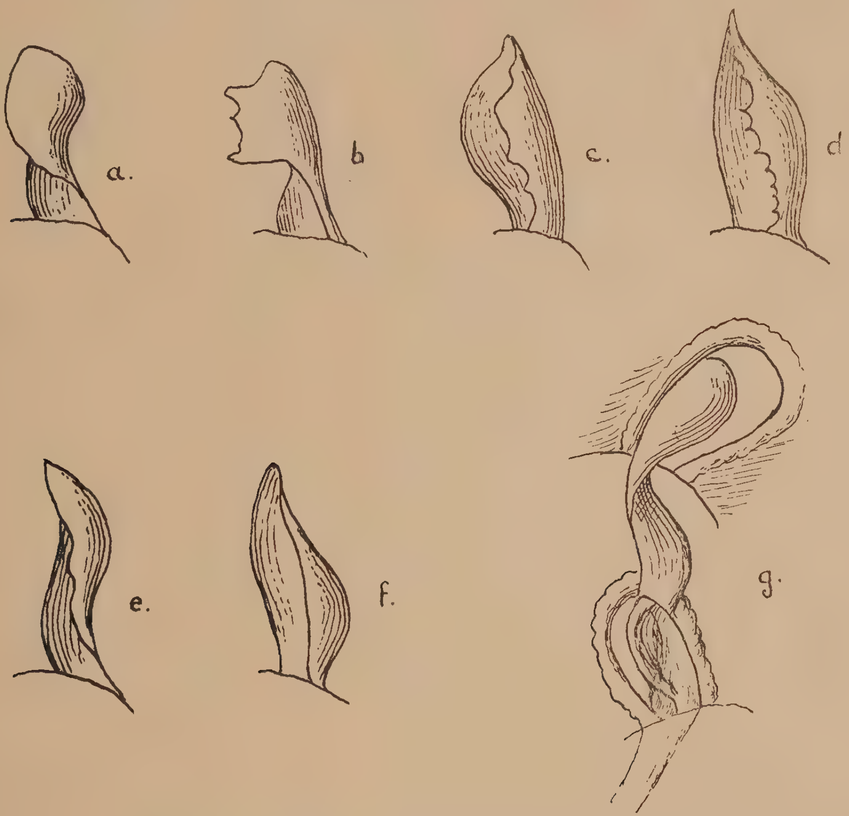


Fig. 157. Toothplates of species of *Virgulina.* a, *V. subdepressa*; b, *V. schreibersiana*; c, *V. complanata*; d. *V. concava*; e, *V. pauciloculata*; f, *V. skageracensis* (after Höglund): g, the structure and situation of the toothplate in the genus *Virgulina*; each plate begins at one side of the former aperture, and is attached to the end of the former toothplate; it runs obliquely towards the next aperture, attached to that side of this aperture which is opposite to the side of the former aperture, where it begun. The free part emerges into the aperture and often shows typical dentations or sawings; in some species it has a totally smooth free side. The free part, emerging into the aperture, is called tooth. The figures are not drawn in a special enlargement.

When describing the genus *Virgulina,* we must bear in mind, that there are only very few characteristics which can be taken into consideration, when the shells are observed only from the outer side. When one has to conclude, whether a shell belongs to *Virgulina,* one has to look first at the initial part. In the case this part really is built up in triserial arrangement, while the further part of the test may be triserial or biserial one can conclude to the genus *Virgulina.*

There are many so-called species which at first sight begin triserially, but upon a closer examination show to be biserially arranged in their initial part. This is the case in those forms of the genus *Cassidulina,* which are slender and have often been looked at as *Virgulina.* Some of these species are now known as *Cassidulinoides,* but others still are named *Virgulina.* Other generations of *Cassidulinae,* e.g. microspheric ones, have been named *Virgulina cornuta,* etc. All those forms, however, with a porcellaneous wall, more or less opaque, do not belong to this genus *Virgulina.* For all real *Virgulinae* are transparent, very hyaline, with very thin walls, always smooth, with very fine pores regularly distributed throughout over the walls. Moreover, *Cassidulinae* always show a very reduced, or very poorly, if at all developed, toothplate, while on the contrary real *Virgulina* shows well developed and very characteristic toothplates.

The aperture of real *Virgulina* is always situated at the end of the overlapping chamber, touching the margin of the chamber, as in *Bolivina.* Always it has a thickened side and a thin-walled other one. At the thickened side the toothplate is attached. This plate always is of a very simple construction; it begins at the opposite wall of the former chamber, attached to the toothplate of it, runs through the chamber with a somewhat curved plate, which is always folded to form a more or less ornamented tooth. This tooth never forms a flanged plate, as in *Bulimina,* and never shows a basal hook, as in *Bolivina.*

As I found, that recent *Virgulina* cannot be determined with certainty with outer characteristics, I studied the toothplates. I then found, that each species shows a very characteristic plate, which forms such constant characteristics, that only with this feature the different species can be distinguished without doubt. When imbedded in ricinus-oil, in cedrum-oil or in Canadabalsam, the toothplate can easily be found (see fig. 157).

Höglund has pointed to the signification of the toothplate in *Virgulina,* as he described his two new species, *V. skagerakensis* and *V. concava.* Even the fact, that he was compelled to create two new species, is a proof of the fact, that the genus *Virgulina* cannot be characterised by outward characteristics. One of the species, found by me in the Pacific, must be identified with his species *V. concava*; I am certain, that formerly it has been described as belonging to *V. complanata* Egger, or to *V. schreibersiana* Czjzek, which must be looked at as a congregate of species.

When, in this paper, I give the species found in my material a name, which has been already used by other authors, it is with some hesitation; for they did not deal with the only typical characteristic, the toothplate.

It is a striking fact, that species of *Virgulina* have only been found in the gatherings South of Sumatra, near the Mentawei-Islands, while in those near Flores not a single specimen has been discovered. All species found have a more or less wide distribution over the Pacific, mostly to the north of the Archipelago.

Virgulina subdepressa Brady
(Figs. 158, 159)

The species occurred in several specimens, all with very large proloculus, at St. 2° 56′ S., 99° 58′ E., depth 405 fathoms. It occurred too in very typical development in both megalospheric and microspheric forms in St. 9° 20′ S., 120° 16′ E., depth 285 fathoms. It has been recorded from numerous stations in the Pacific. It is remarkable, that Brady's figures all show a large proloculus also. Thus it may be a generation of another species which outwardly may show other characteristics. This can only be stated by the study of the toothplate. In my material no forms with smaller A-proloculi and eventually other outward characteristics, but with the same toothplate, were observed.

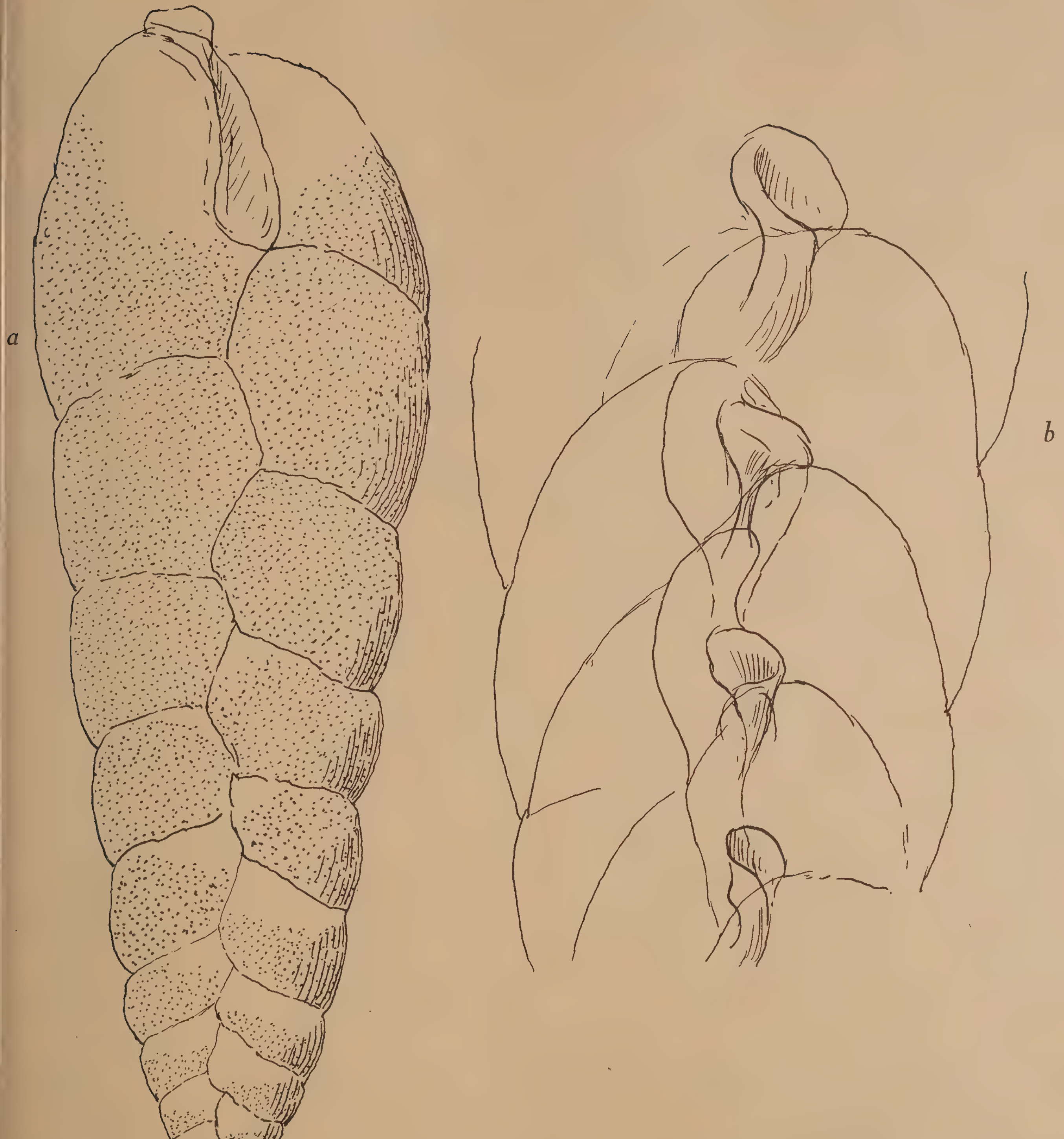


Fig. 158. *Virgulina subdepressa.* a, microspheric specimen, × 480; b, optical section, showing the simple toothplates which, in several respect, resemble those of *Globobulimina.* × 630.

Another characteristic of the shells is, that the pores in most chambers did not reach the aperture, so that a triangular part of the chamber remains without pores.

The length of the specimens is 0,33 mm, the breadth 0,11 mm. These measures are much smaller than those, given by Cushman. It is possible, that some generations of *Cassidella* have been described as *Virgulina subdepressa*; these forms always attain a much larger size. Description of the megalospheric form:

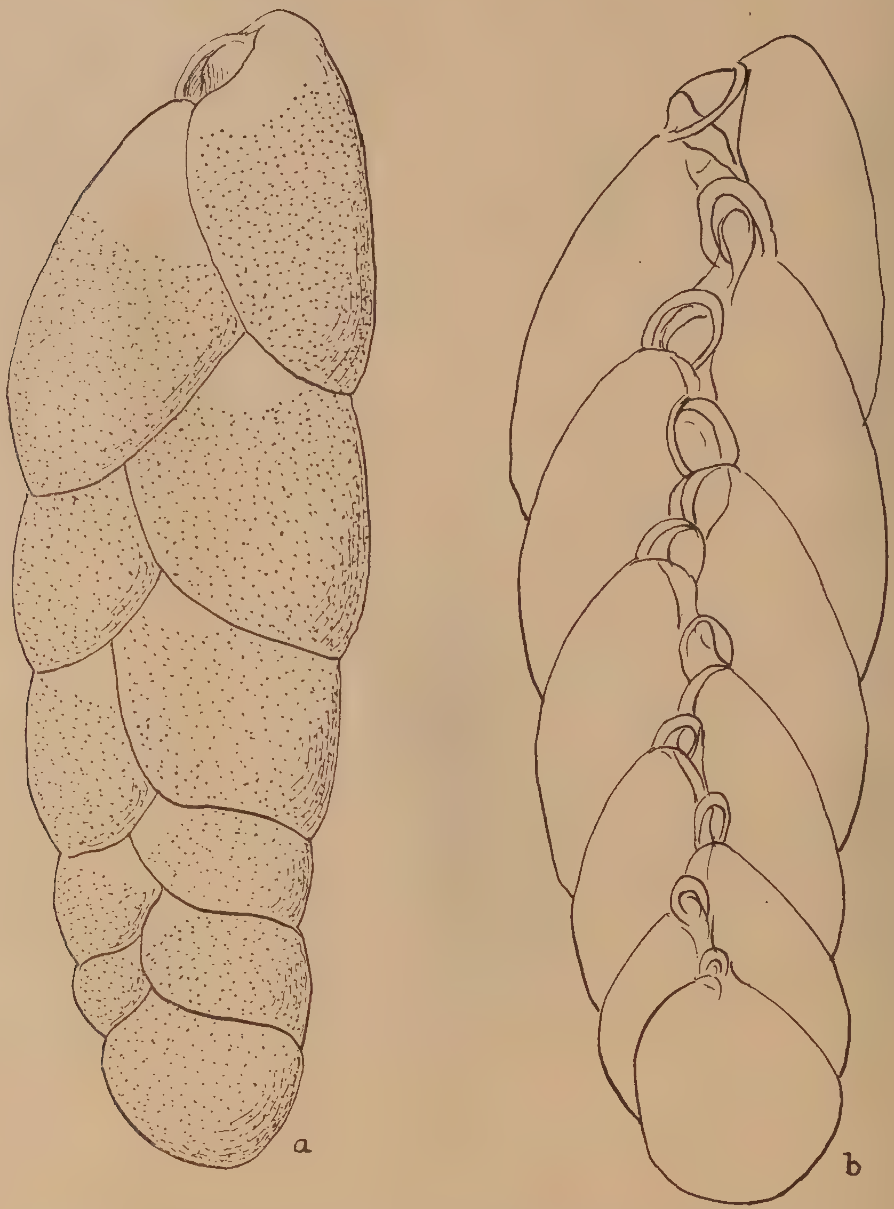


Fig. 159. *Virgulina subdepressa* Brady. Megalospheric specimens. a, individual, showing punctulation; b, optical section through another specimen, showing toothplates and apertures. × 480.

Test elongate, rounded at initial end, somewhat tapering towards the apertural end, slightly depressed, margin rounded. Chambers much higher than broad, overlapping, somewhat inflated.

Walls hyaline, with very fine pores, leaving a triangular part free near the axis and near the aperture. Aperture a rounded oval opening at the suture, with one border higher than the other one, and with slightly protruding tooth which shows no sawings or teeth. Length 0,33 mm, width 0,11 mm.

Microspheric form:

Test very elongate, tapering from the beginning, with pointed initial end without spine. Margin rounded. Chambers as high as broad, overlapping, slightly inflated. Walls quite hyaline, with very fine pores, leaving in the initial part a triangular distal part near the axis free, but in the older chambers this hyaline part is covered by the porous walls of the overlapping chambers. Aperture a rounded oval opening at the suture, with slightly protruding toothplate which is simple, showing a broader part at its end; border of the plate smooth. Length 0,35 mm, width up to 0,13 mm.

Virgulina schreibersiana Czjzek
(Figs. 160, 161)

A very typical species occurred in the gatherings south of Sumatra and in those near Flores. The depth ranged from 377-777 fathoms. Some specimens had an apical spine, others had not, however. Most specimens are short and robust, though very small and thin, with very thin walls. They are somewhat compressed, and the description of Cushman (Lab. For. Res., spec. publ., 9, 1937, p. 14) agrees with them.

The toothplate shows a slightly curved folded back, and the tooth is short, projecting through the aperture with its abrupt, axe-like free end which shows two or three saw-teeth. This typical toothplate cannot be confused with that of other Virgulinae. Length of shell up to 0,31 mm, which is rather small, as Cushman mentioned a length up to 1 mm.

Specimens with large proloculus of about 37 μ, showed a pointed initial end, while those with smaller proloculus (about 18 μ) lacked the point. I found the same difference in my material from the Ammontatura in the Mediterranean (Publ. Staz. Zool. Napoli, Vol. 12, p. 118, fig. 31).

When studying fossil material, I found, that several authors have described generations of *Cassidella* as *Virgulina schreibersiana*, so Ten Dam and Reinhold (Med. Geol. Stichting, Ser. C-V-2, Die Stratigraphische Gliederung des Niederländischen Oligo-Miozäns nach Foraminiferen, 1942, p. 82, Pl. 5, fig. 14). I tested the type-specimens, and came to the conclusion, that *Virgulina schreibersiana* of these authors is nothing else but one of the generations of *Cassidella*, which will be described later in this paper. So it is possible, that the length, given by Cushman (up to 1 mm) is that of this *Cassidella*-form.

Description of the megalospheric forms of this species:

Test elongate, broadest part about the middle, at both ends somewhat pointed, slightly compressed, margin rounded. Chambers higher than broad, pointed towards the apertural end, in the megalospheric form biserially arranged throughout. In the A_2-form with an apical spine, which is always short and stout, in the A_1-form without spine. Walls hyaline, with fine pores all over the chamber-walls, even near the aperture. Aperture a high, narrow slit with the base at the suture, and a protruding, short and irregularly sawed tooth. Length up to 0,31 mm, largest width 0,13 mm.

The specimens I found in some other gathering, viz. at 2° 6′ S., 99° 54′ E., depth 778 fathoms and at 8° 18′ S., 118° 39′ E., depth 880 fathoms, were much larger than those, described above. At first sight I thought to deal with quite a different species, though the general aspect of the specimens was quite the same, with its smooth finely punctate chamberwalls and its apical spine. But the study of the toothplate at once revealed their identity with the poorly developed specimens, described above, and, moreover, the size of these tests was that, described by Czjeck. The specimen from 2° 6′ S., 99° 54′ E. had a length of 0,37 mm, breadth 0,17 mm, the other from 8° 18′ S., 118° 39′ E. showed a length of 0,48 mm and a breadth of 0,18 mm.

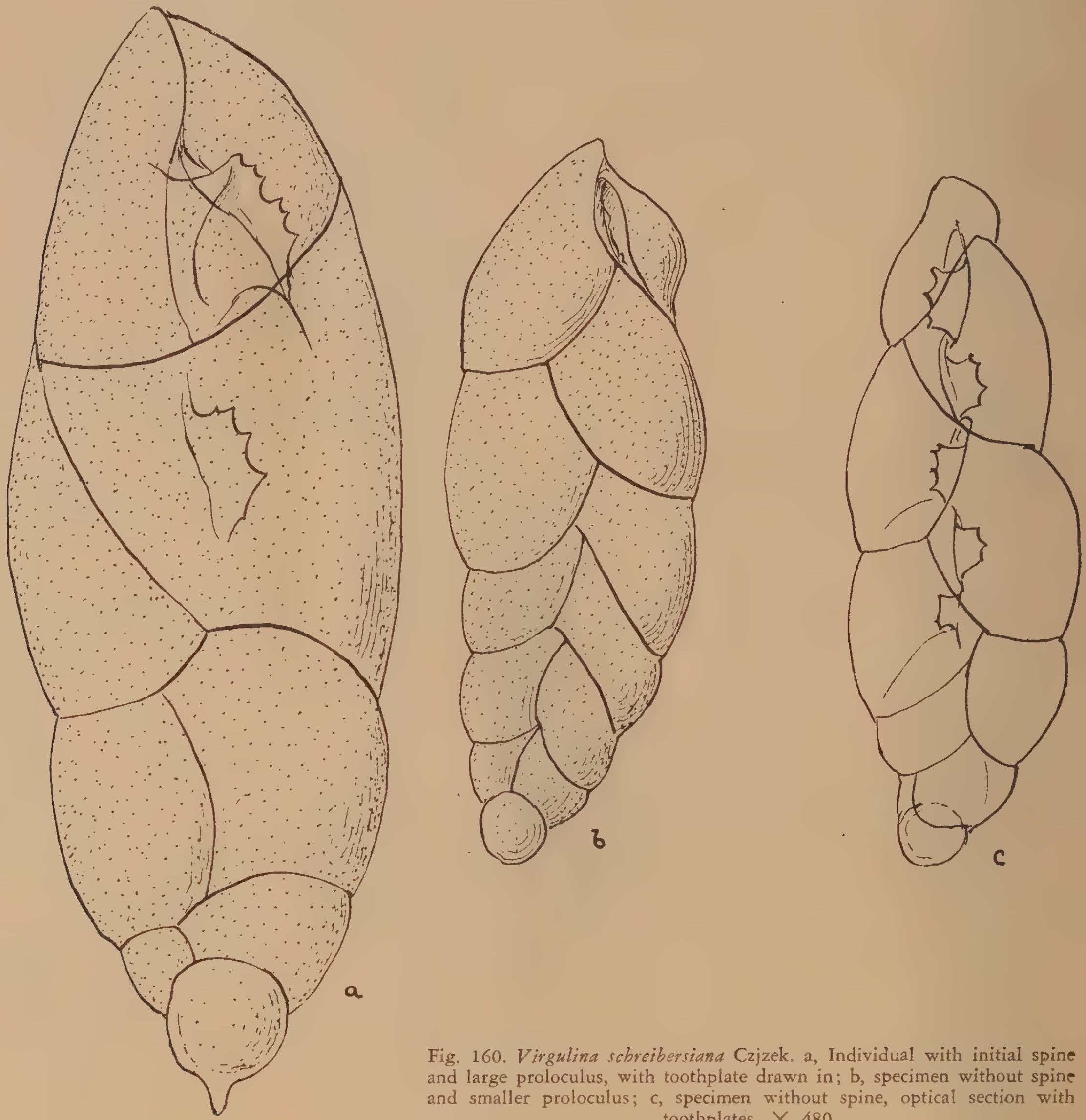


Fig. 160. *Virgulina schreibersiana* Czjzek. a, Individual with initial spine and large proloculus, with toothplate drawn in; b, specimen without spine and smaller proloculus; c, specimen without spine, optical section with toothplates. × 480.

So I now am certain, that here the true *V. schreibersiana* is found (Fig. 161).

Höglund (1947) in his treatise on *V. skagerakensis* mentions his hesitation in giving Goës' specimens the name of *schreibersiana*. In fact, the toothplates of *V. skagerakensis* and those of *V. schreibersiana* are not in the least resembling each other.

It may be, that, what has been called *Bulimina elegans*, var. *exilis* Brady includes specimens of *Virgulina schreibersiana* as well as of *V. concava* Höglund.

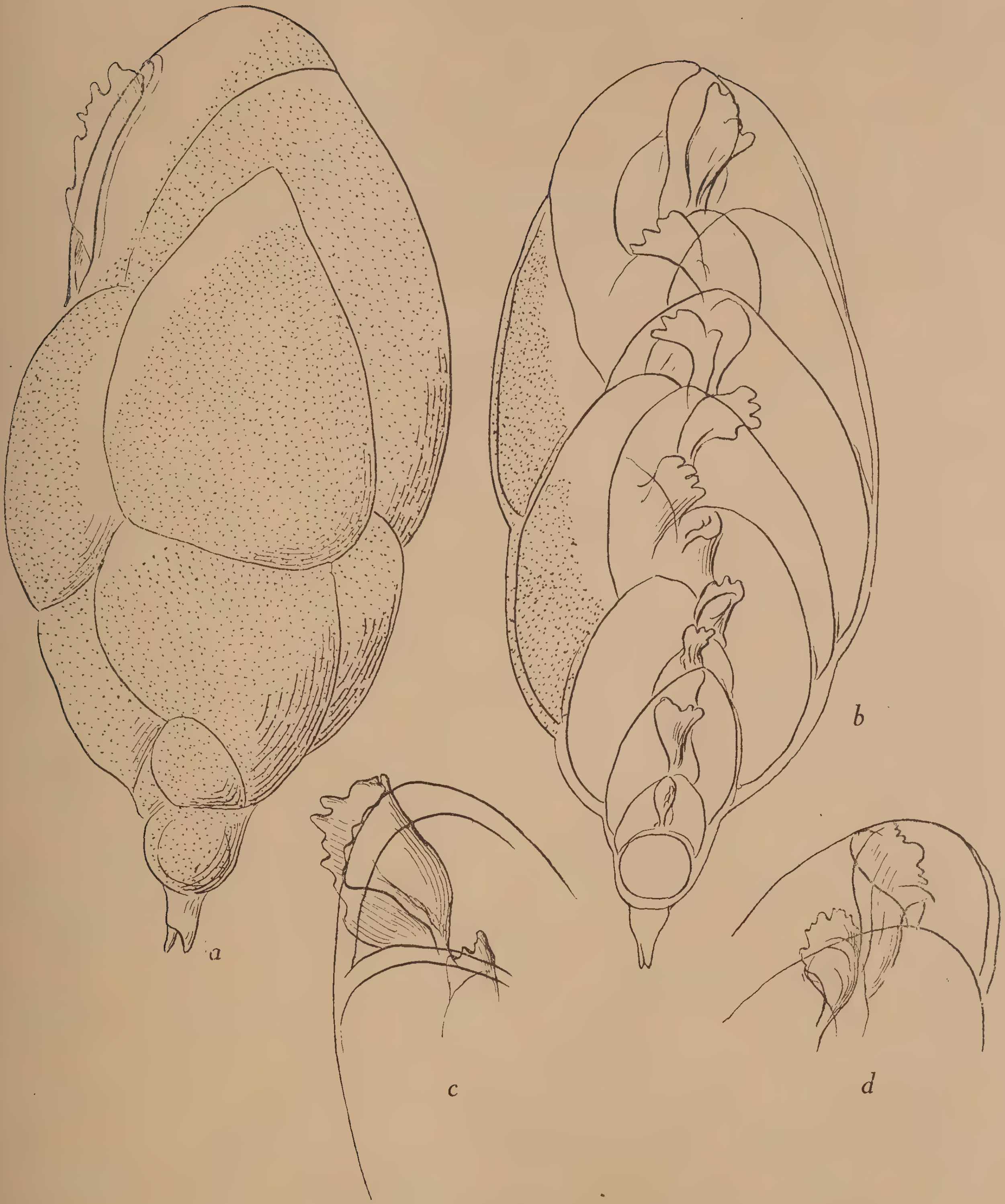


Fig. 161. *Virgulina schreibersiana.* a, whole test; b, optical section; c and d, toothplates; × 480.

Höglund described exhaustively a species, which he called "*Bulimina*" *fusiformis* Williamson. On p. 233 (1947) he says however: "As far as our knowledge of the family *Buliminidae* goes at present, it would seem more to the point to attribute the species to the genus *Virgulina*. Since, however, the genus *Virgulina* is not yet, in my opinion, sufficiently clearly defined, and the establishment of a new genus seems inadvisable at the moment, I prefer, for the present, to stick to Brady's version of Williamson's original denomination". When comparing Höglund's figures of the whole test as well as of the structure of the toothplate with my figures, given here of *Virgulina schreibersiana,* there is no doubt as to the very close relationship of the two species. In the Pacific specimens the terminal aperture was not found, and many of them show a terminal spine, others, however, were lacking it. But the toothplates are identical, and the latter is a very constant character. In the Norvegian specimens the tendency to become uniserial is found. But here too the specimens show all characters of real *Virgulina.*

Virgulina complanata Egger.

(Fig. 162)

The species occurred in several specimens in the gatherings south of Sumatra, about 2° S., 99° E., at depth 377 and 582 fathoms. It showed the typical slender form of *V. complanata,* compressed, with or without initial spine. The chambers are much inflated and the whole test very much resembles the figures, given by Höglund (197) for his *Virgulina skagerakensis.* It may be, that our species is even identical with his species, as the toothplate seems to be identical also. Höglund does not describe the tooth itself, so it seems, that this tooth does not possess any ornamentation. This is in agreement with our species, as here the folded and most simple toothplate shows a free border which is nearly straight, without any real sawing. The folded back is as much curved, as it has been figured by Höglund in his fig. 272.

Length up to 0,40 mm, which is very small again, in respect to the measures, given by Höglund and Cushman. It seems that conditions are far from favourable in those regions south of Sumatra.

Höglund mentions, that Goës labelled specimens of his *V. skagerakensis* as *V. schreibersiana,* which species shows to have been a compilating-type for all slender specimens found by older authors (Höglund, H., l.c. 1947, p. 255). I will cite here Höglund's description, as it agrees in all respects with the megalospheric forms, I found in the Pacific, except for the size and the lack of a spine in the A_2-generation of the Pacific species. As, however, size and spines are not of great specific value in all *Virgulinae,* this is no reason to consider this species, here given under the name of *Virgulina complanata* Egger, distinct from Höglund's *V. skagerakensis.*

Description:

"Test elongate, slender, about four times as long as broad, slightly compressed, biserial throughout in the megalospheric as well as in the microspheric form, often somewhat twisted, periphery rounded, slightly lobulate, the initial end with one very distinct spine (sometimes two, occasionally three spines); chambers distinct, depressed, increasing rather rapidly in size as added, inflated; sutures distinct, depressed, oblique; wall smooth, very finely and densily perforate; aperture narrowly elongate, unsymmetrical, with a double-folded tongue. "

Length up to 0,40 mm, breadth up to 0,10 mm.

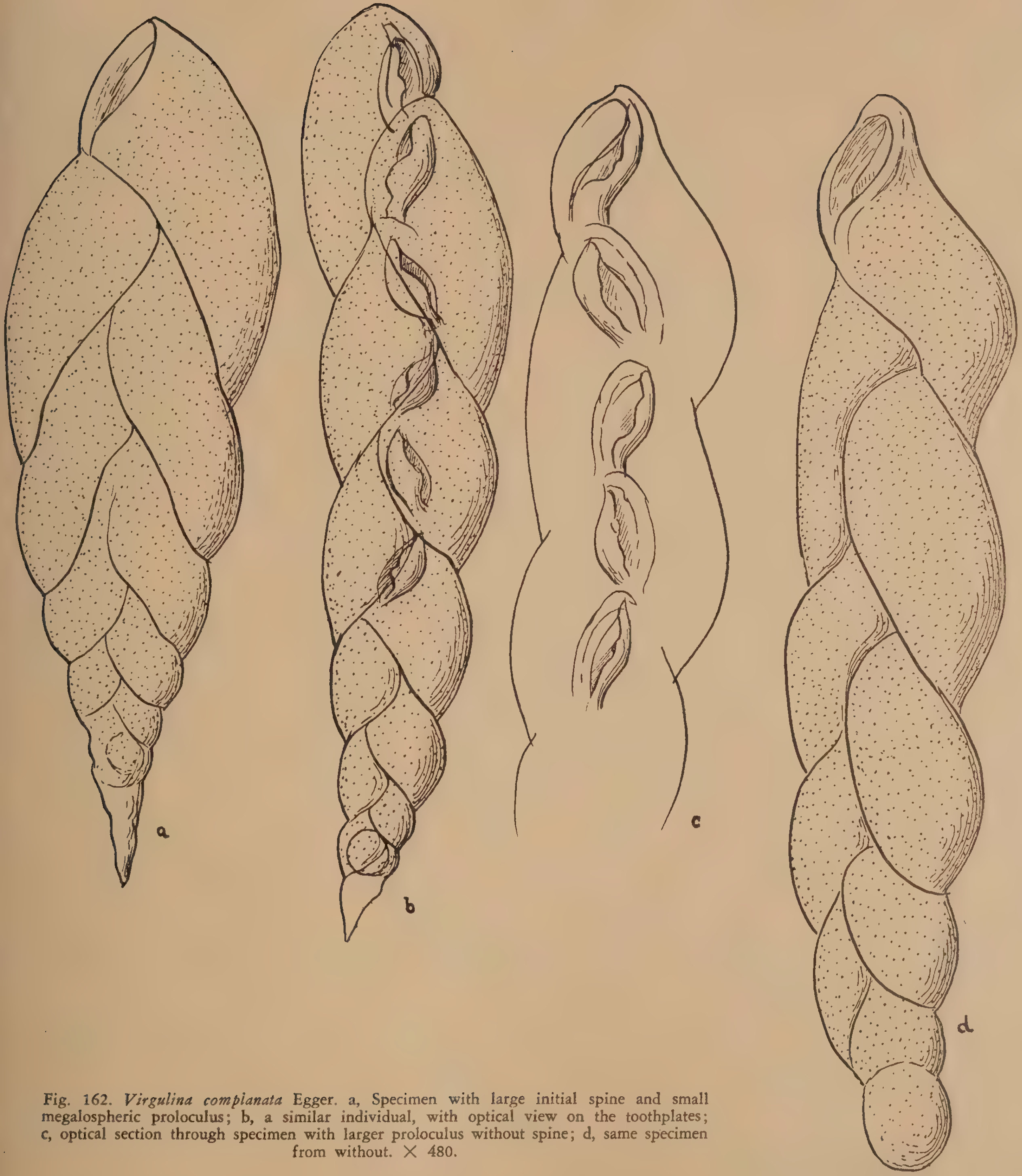


Fig. 162. *Virgulina complanata* Egger. a, Specimen with large initial spine and small megalospheric proloculus; b, a similar individual, with optical view on the toothplates; c, optical section through specimen with larger proloculus without spine; d, same specimen from without. × 480.

Virgulina concava Höglund
(Fig. 163)

Small specimens, obviously belonging to the same species, Höglund met with in Gullmar Fjord, were found in a gathering south of Sumatra at a depth of 582 fathoms. They showed an initial spine, and the typical inflated and long chambers of *V. complanata,* but the toothplate was identical with that, described and figured by Höglund. The toothplate runs from the thick side of the former foramen towards the opposite side of the aperture, only slightly curved at its folded back, while the free side of the tooth shows the fine sawing which is characteristic for the species. The tooth is nearly as long as the whole toothplate, this in contrast with that of my *V. schreibersiana,* in which species the sawed tooth is very short, only half as long as the plate itself.

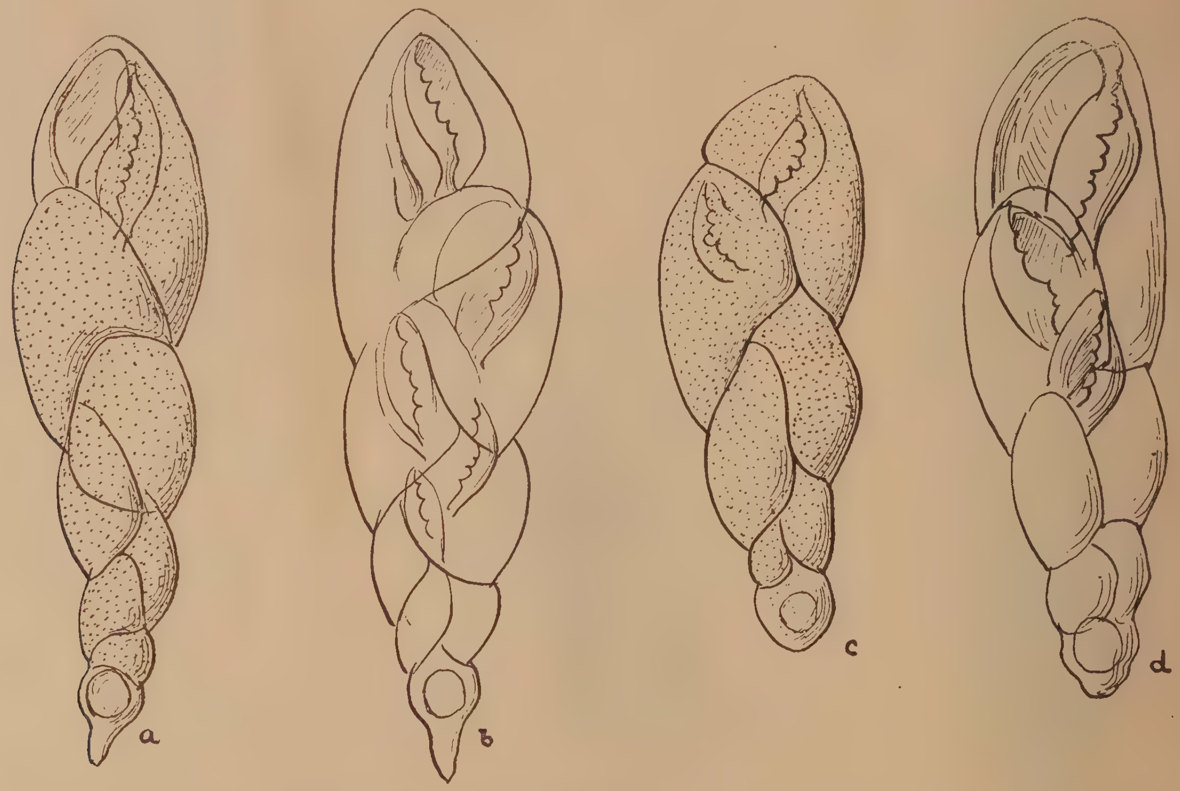


Fig. 163. *Virgulina concava* Höglund. a and b, specimens with spines, b optical section with toothplates; c and d, specimens without spines, showing toothplates in optical section. × 480.

Length up to 0,23 mm.

Some very poorly developed specimens, without spine, were found at a depth of 377 fathoms near the same locality (fig. 163, c and d).

As Höglund's very accurate description agrees fully with the specimens, found here, I shall cite his description (Höglund, H., 1947, l.c., p. 258):

"Test elongate, triserial, in the adult portion tending to become biserial, twisted throughout, in small specimens about 2-5 times and in large ones 4-5 times as long as broad, very slightly if at all compressed, periphery strongly lobulate, the apical end with a distinct spine (sometimes two); chambers inflated, oval in broad view, nearly semicircular in transverse section, increasing rapidly in size as added, sutures distinct, depressed; wall comparatively thick, smooth, very finely and densely perforate; aperture large and wide with a narrow lip at one side and at the other a large tongue bending under the lip and partially closing the opening."

Length up to 0,23 mm; 0,23 breadth up to 0,07 mm.

*Virgulina paucilocula*ta Brady
(Fig. 164)

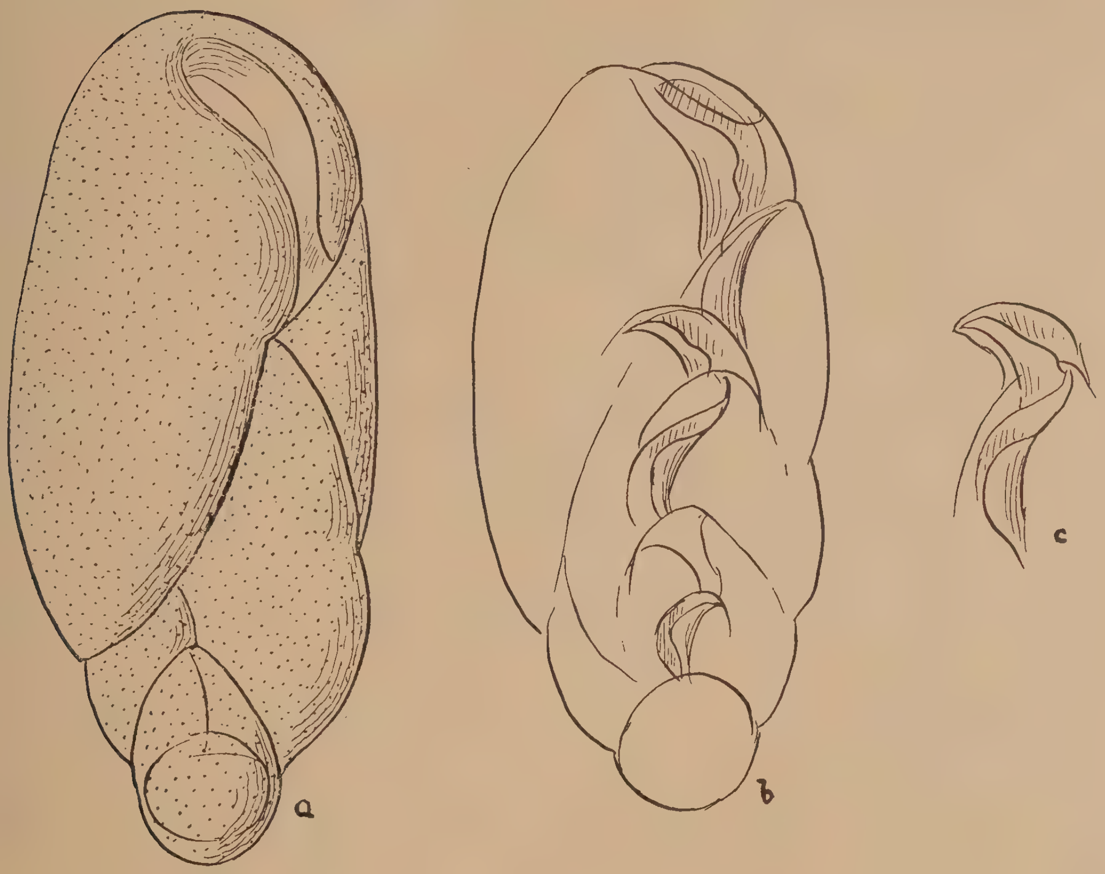


Fig. 164. *Virgulina pauciloculata* Brady. a, specimen from without; b, another individual, optical section, showing toothplates; c, toothplates of two successive apertures; × 480.

This short species, with its few chambers, occurred in two megalospheric specimens (diameter of proloculus about 40 μ) in a gathering south of Sumatra, depth 377 fathoms. The toothplate is very simple, the folded back slightly curved, the tooth itself very narrow and smooth, without any sawing. Length of shells 0,25 mm.

Description of the megalospheric form:

Test two times as long as broad, compressed, with protruding proloculus and rounded initial part, somewhat depressed, broadest near the end which is rounded. Chambers few, two times as high as broad, much overlapping and somewhat inflated, with broad and blunt apertural end. Walls smooth, hyaline and finely porous throughout. Aperture an oblique rounded slit based on the suture, tooth not protruding and invisible from without. Toothplate simply folded, with somewhat curved free part.

Length up to 0,25 mm, breadth 0,13 mm.

It may be, that this *Virgulina pauciloculata* is closely allied to the genus *Cassidella,* as the toothplate resembles that, found in that genus.

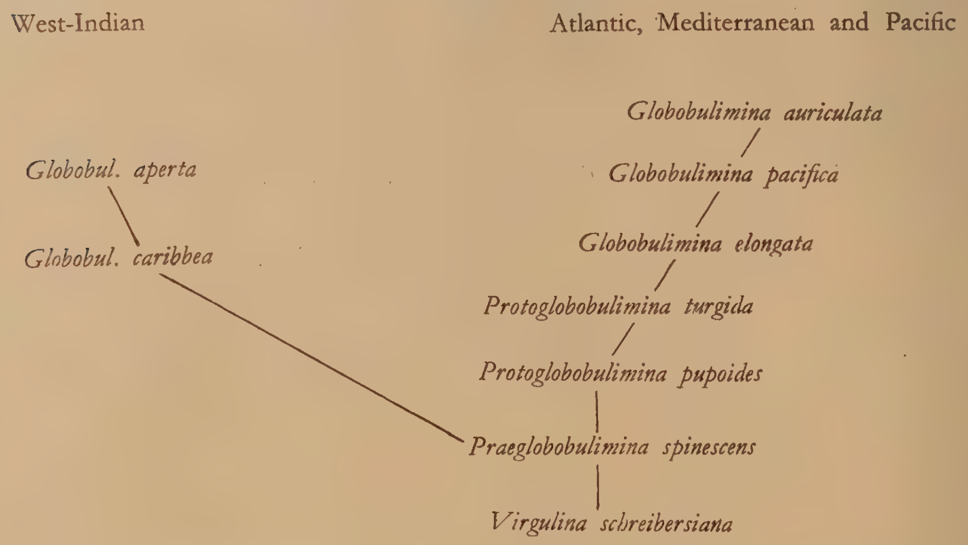
Genus **Praeglobobulimina** nov. genus

This genus had to be erected for those globobulimine species which show most of the outer characteristics of *Globobulimina,* but have a toothplate which is quite different from that, found in real *Globobulimina.* Till now only the species *Bulimina pyrula* var. *spinescens* is known to belong to this genus. The generic characteristics are:

More or less elongate, with thin-walled, inflated chambers which overlap the preceeding ones. Large oviform megalospheric proloculi. Wall smooth, except for the apical sutures which show distinct spines. Pores distinct, with large distances between, and elongate. Aperture elongate, at the base of the suture, which shows the characters of a closed one, though there seems to be in reality an open aperture. The toothplate shows at its free part fine dentations, while the basal part of the free folded part is reduced.

Praeglobobulimina does not show the fine pores between the elongate ones, as described by Höglund; he found, that in the species *Globobulimina* a, found in the Gulf of Mexico by him, fine pores were absent too. As this characteristic seems to be of high generic value, it may be, that those *Globobuliminae* without fine pores are deriving from *Praeglobobulimina,* whereas those with finer pores are deriving from *Protoglobobulimina.*

Scheme of development of the
Globobulimininae


West-Indian
Atlantic, Mediterranean and Pacific
Globobulimina auriculata
Globobul. aperta
Globobulimina pacifica
Globobul. caribbea
Globobulimina elongata
Protoglobobulimina turgida
Protoglobobulimina pupoides
Praeglobobulimina spinescens
Virgulina schreibersiana

Regarding the structure of the pores (simple round larger pores, elongate larger pores, fine pores) it may be, that two groups of *Globobulimina* have arisen independently from each other.

The one group is found in the Western Atlantic, is lacking fine pores and often shows, especially in younger shells, the larger pores rounded. It may have been derived from *Praeglobobulimina.*

From *Protoglobobulimina pupoides* or forms, resembling that living species, have derived all those forms, which show fine pores between the elongate larger ones, at least in full-grown tests. They are found in the Eastern Atlantic and the Northern part of it, the Mediterranean, and the Pacific. I cannot believe that the genus *Desinobulimina* is of any value, and so I have dropped it.

The type of the genus is *Praeglobobulimina spinescens* (Brady).

Praeglobobulimina spinescens was found in the eastern part of the area only. *Globobulimina elongata* has been found in the western part only and *G. pacifica* in both areas.

Praeglobobulimina spinescens (Brady)
(Figs. 165-167)

I found several specimens of what has been called by Brady *Bulimina pyrula* var. *spinescens* (Cushman, Nat. Mus. Bull. 71, pt. 2, p. 78, figs. 128, 129; Brady Challenger-Report, p. 400, pl. 50, figs. 11, 12).

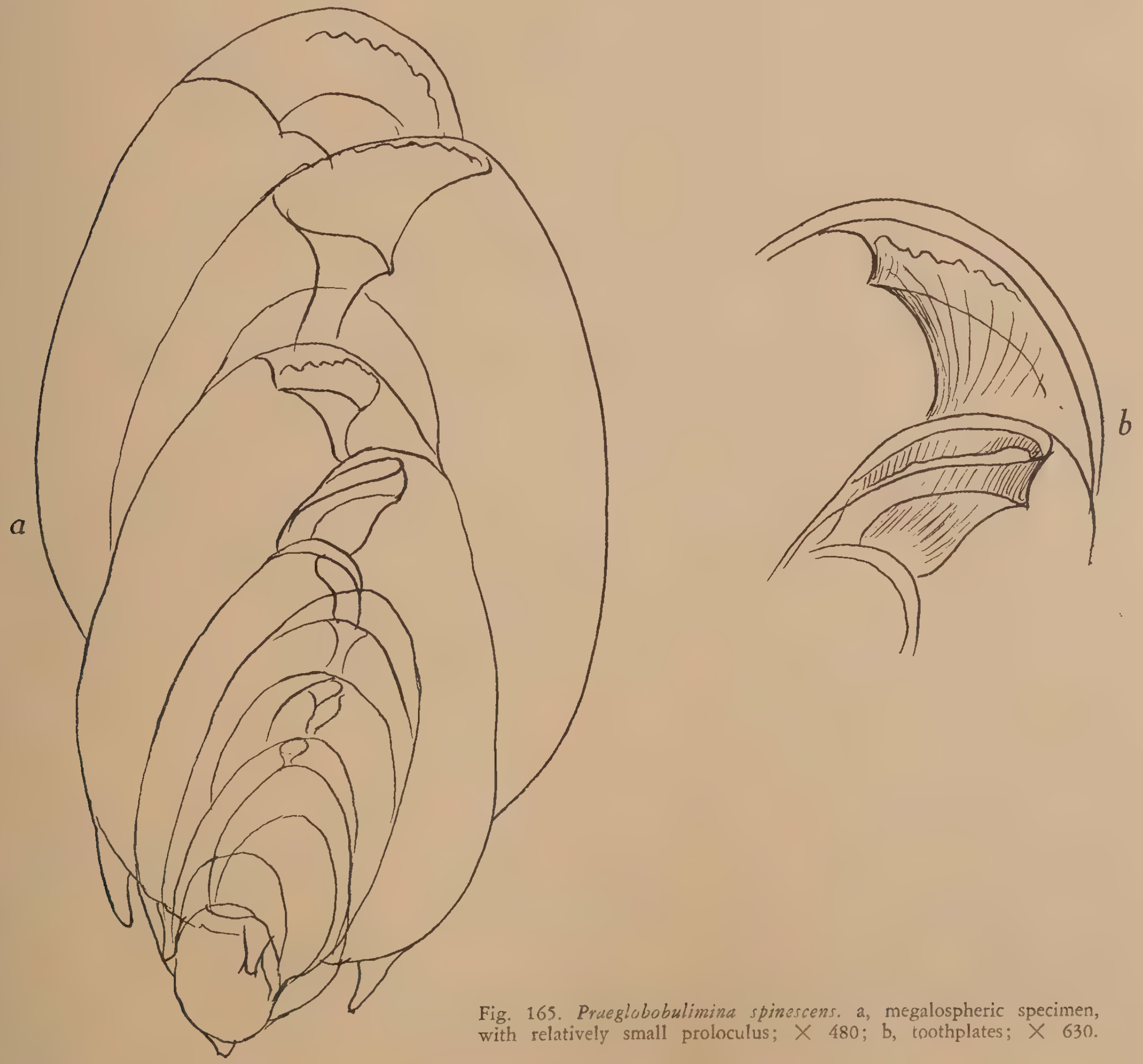


Fig. 165. *Praeglobobulimina spinescens.* a, megalospheric specimen, with relatively small proloculus; × 480; b, toothplates; × 630.

It was found at St. 8° 18′ S., 118° 39′ E., depth 880 fathoms; St. 262, 5° 53′ S., 132° 48′ E., depth 560 m; Cushman reported it from off Japan, depth 440 fathoms.

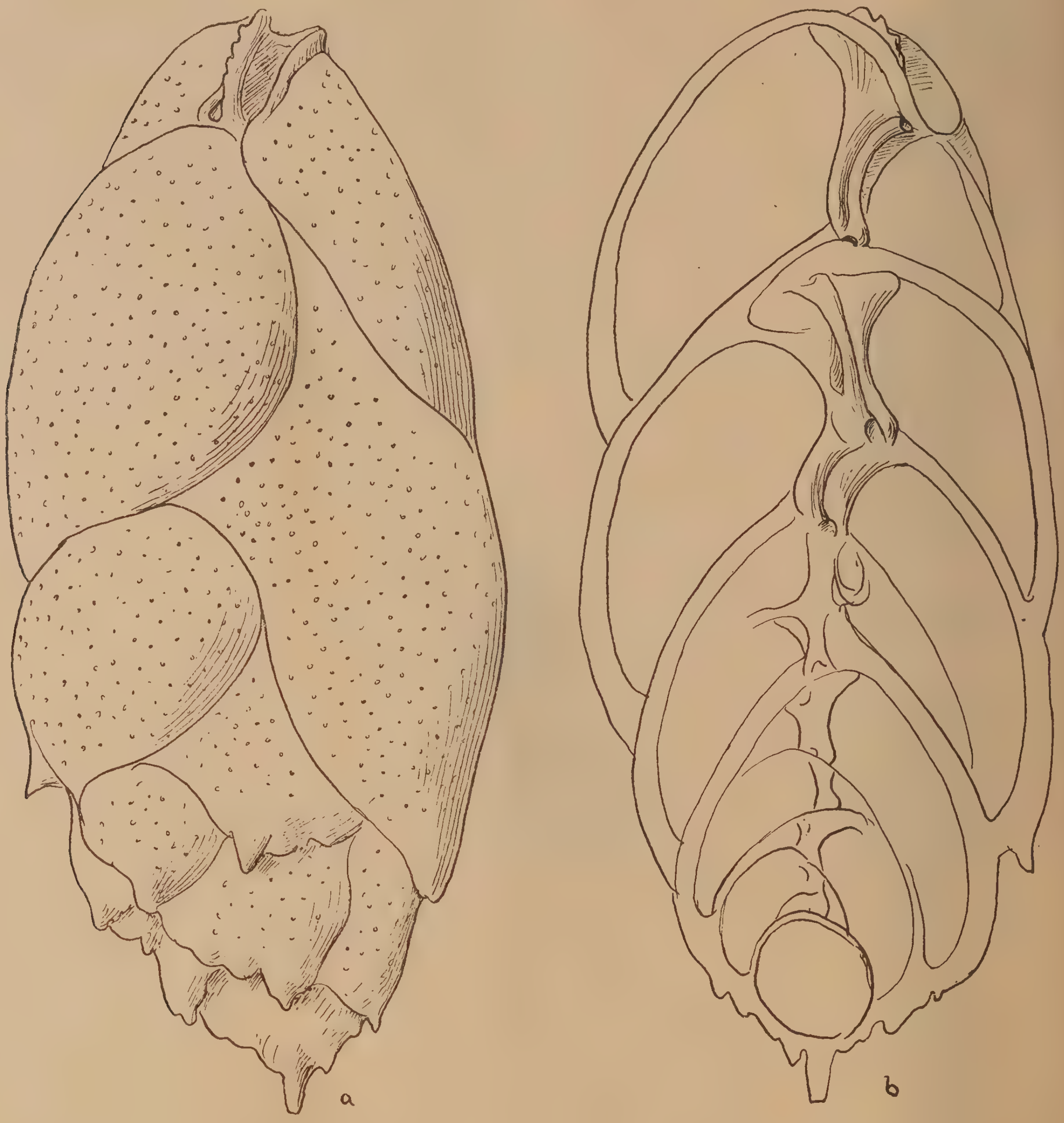


Fig. 166. *Praeglobobulimina spinescens.* a, specimen of the A2-generation; b, section through same specimen; × 480.

The peculiar test with its thin walls and overlapping chambers, leaving little to be seen from the initial chambers, and the pointed spines at the initial end of the last-formed chambers, are typical characteristics.

The megalospheric proloculus shows already the typical character of *Globobulimina:* the oval or ovoid form. The walls are already thin, but the scattered fine pores in it show not the elongate form. The aperture is not a wide, glaring opening, as in typical *Globobulimina,* but a more narrow, elongate slit, and the toothplate does not have the typical form of a pillar, as is found in typical *Globobulimina,* but shows more or less the form of several species of *Cassidulinoides,* e.g. that of *C. mexicana.* Its attached part runs along one of the borders of the mouth, whereas the free folded part forms only a narrow band along the other side of the aperture. This peculiarity points to a reduction of the plate. This reduction thus has mainly gripped the free part, leaving from it only

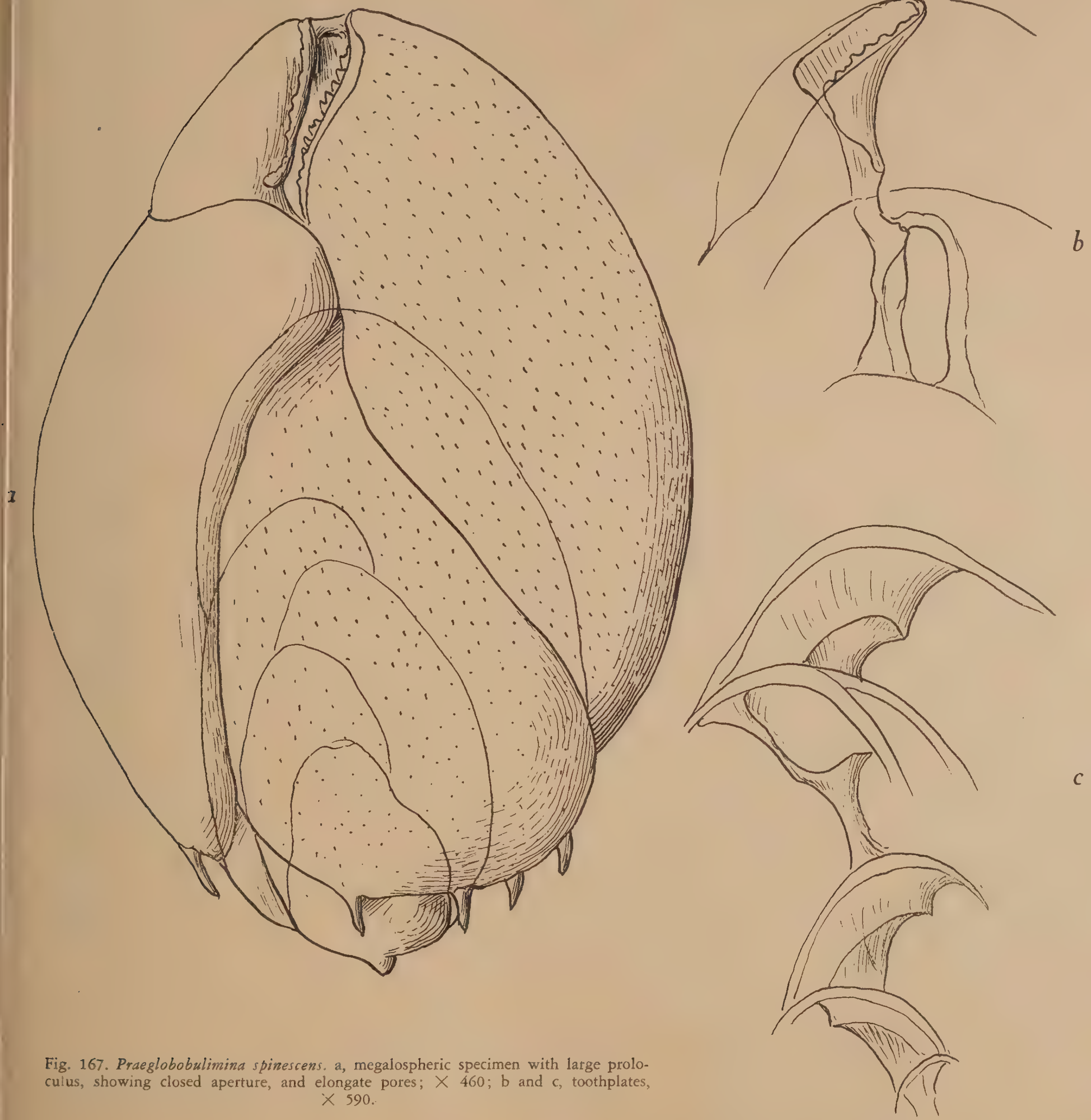


Fig. 167. *Praeglobobulimina spinescens.* a, megalospheric specimen with large proloculus, showing closed aperture, and elongate pores; × 460; b and c, toothplates, × 590.

a narrow strip along the border of the aperture. I am convinced, that the so-called collar of the apertural border at the side, at which the toothplate is not attached, is nothing but the remainder of this strip, found here. In this way, the whole test of our species shows at one side typical features of real *Bulimina* with larger pores resembling in many characters the test of *Bulimina pagoda* Cushman (larger pores, spines at basal sutures of chambers, narrow aperture), at the other hand typical features of *Globobulimina* (reduced toothplate, free part of toothplate becoming a collar of aperture, ovoid proloculus in megalospheric form, thin walls).

This mingling of characters of two genera is typical enough to create for this species a new genus, which I will call *Praeglobobulimina.*

Length of test up to 0,40 mm; breadth up to 0,28 mm; diameter of megalospheric proloculus 30 and 60 μ.

In *Praeglobobulimina* the pores only show the elongate form in adult specimens; no fine pores were found between.

So this genus may be the ancestor of those *Globobuliminae* which do not show finer pores as well.

Genus **Protoglobobulimina** nov. genus

This genus shows some characteristics (thick walls, inflated chambers not fully overlapping the former ones, toothplate plate-like) of typical *Bulimina,* while other characteristics (shape of aperture, reduction of free folded part of toothplate, elongate pores between the finer ones) point directly toward the genus *Globobulimina.* The elongate test shows in megalospheric forms the typical ovoid proloculus, characteristic of *Globobulimina.*

The toothplate of this genus is much more plate-like than that of typical *Globobulimina,* and the thicker walls show, that it is not so fully adapted to pelagic life, as real *Globobulimina.* I believe, that several fossil species of so-called *Bulimina,* in reality belong to this genus.

As the shape and size of pores in the groups of those Foraminifera deriving from Cassidelline ancestors, seem to be very valuable characters of generic importance, it may be, that those species of *Globobulimina* which show fine and coarser (elongate) pores together, have derived from ancestors, closely related to *Protoglobobulimina pupoides.* If this is the case, the genus *Globobulimina* is of polyphyletic origin, one part of its species deriving from *Praeglobobulimina* (showing only the coarser elongate pores) whereas other species derive from *Protoglobobulimina* (both kinds of pores).

The type of the genus is *Protoglobobulimina pupoides* (d'Orbigny).

Protoglobobulimina pupoides (d'Orbigny)
(Fig. 168)

This species, abundant in the shore-gatherings at Rimini, Adria, has always been looked at as a real *Bulimina.* Closer examination however showed me, that it is much more like a *Globobulimina.* I shall describe it shortly here, first, as it occurs in the vicinity, as Cushman mentions it from the Philippines, and as I found some dubious specimens, which may possibly be identical with

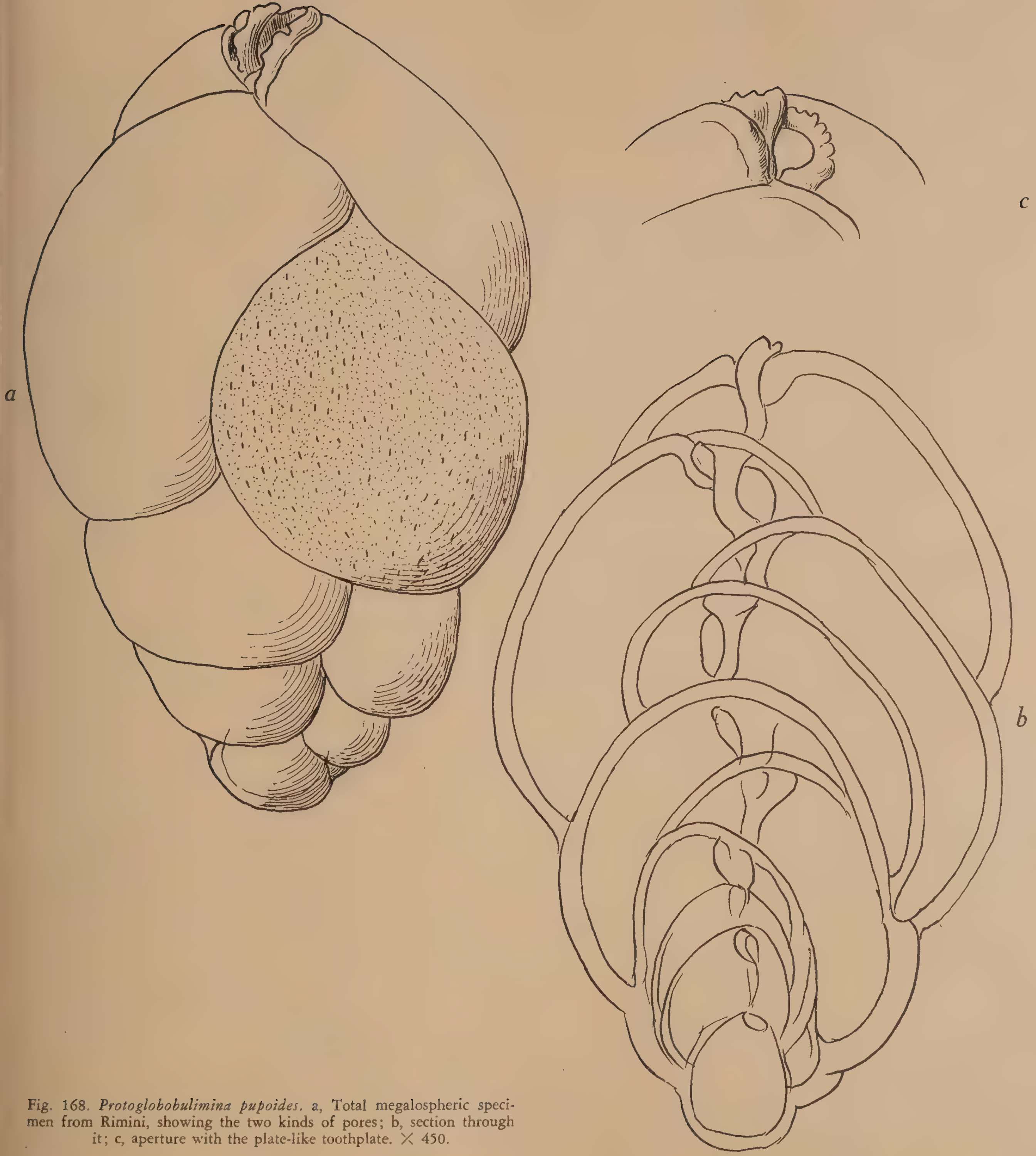


Fig. 168. *Protoglobobulimina pupoides.* a, Total megalospheric specimen from Rimini, showing the two kinds of pores; b, section through it; c, aperture with the plate-like toothplate. × 450.

our species, and secondly, while several of those larger smooth *Buliminae* show to be nothing but *Globobulimina* in the sense, given by Höglund.

As main characteristics of *Globobulimina* I will expose here:

Aperture more or less wide, loop-shaped, mostly with distinct collar. Walls of chambers mostly smooth, with elongate larger pores in the adult and often with finer pores between the larger ones. Last-formed chamber shouldering the aperture, and often both sides fuse together beneath the aperture to form a single suture running from base of aperture toward initial part. In the more primitive species this is not the case, and then the aperture remains "open". Toothplate reduced into a straight pillar, folded slightly to form a trough, which in some cases gets a second foramen at the base of the real one; in higher forms the free part of the plate, situated at the top of the folded pillar, is fan-shaped; in the more primitive species it ends bluntly. In the most primitive forms it has retained more or less its plate-form, as in *Protoglobobulimina pupoides* and in *Praeglob. spinescens.*

Walls relatively thin. In the primitive forms the walls are thicker than in the more adapted forms. This adaptation always goes in the direction of pelagic life, and then the chamberwalls may become extremely thin, the chambers totally overlapping, and the suture underneath the aperture may even obliterate totally, as was shown by Höglund in *Globobulimina auriculata* var. *gullmarensis* Höglund. So, when studying smooth, larger *Buliminae,* one has to give attention to the pores (elongate pores without doubt point to *Globobulimina*), then to the toothplate (a pillar-like toothplate points to *Globobulimina*). In the third place one must give his attention to the sutures underneath the aperture (open sutures point to primitive, closed suture points to higher organised forms of *Globobulimina*). In the fourth place the overlapping of the chambers must be taken in consideration (primitive forms show the initial chambers in the megalospheric forms; higher adapted forms do not, but possess overlapping chambers).

Protoglobulimina pupoides (d'Orbignu) from Rimini and elsewhere shows the primitive form of the genus. The chambers possess relatively thick walls, with two kinds of pores, very fine ones, only visible with higher magnification and in a clarifier, and larger ones which show the typical character of the genus; they are rounded at the inner side of the wall and lengthened toward the outer side.

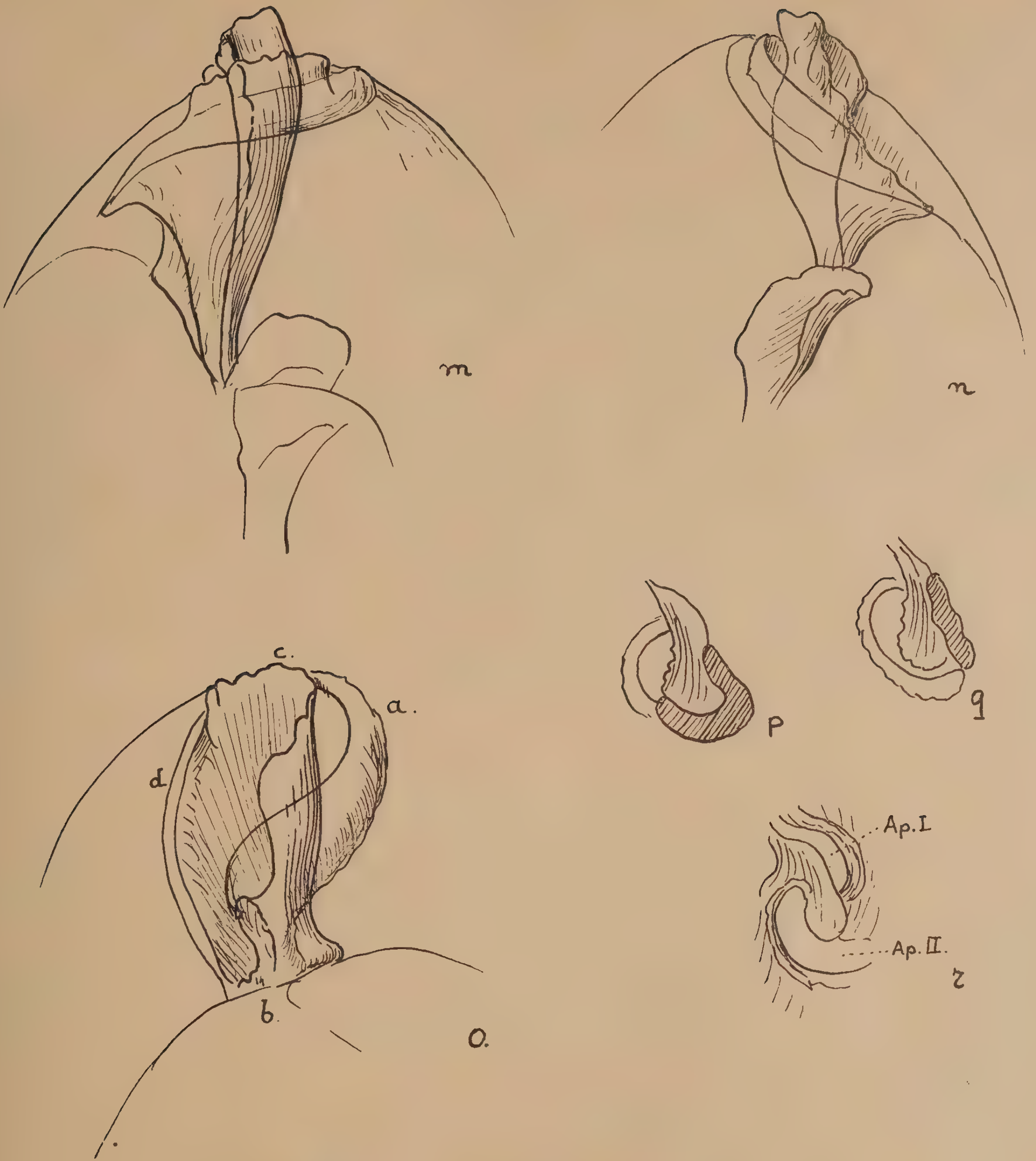
The chambers are overlapping, but no more than in many other species of real *Bulimina.* So the whole apertural part of the test is visible. The aperture is open, and loop-shaped, provided with a distinct collar with more or less sawed borders. The toothplate is a thick, straight plate, flat and heavy, slightly protruding from the aperture with its free end, not showing the high development of typical recent *Buliminae.* The proloculus shows not the globular shape in the megalospheric form of real *Bulimina,* but the ovoid one of *Globobulimina,* with its narrow opening at the end. Length about 0,35 mm, breadth 0,21 mm. At Rimini abundant, in the Archipelago rare.

The species was found in scattered specimens in the Stations:
2° 2′ S., 99° 48′ E., depth 460 pathoms; 9° 06′ S., 121° 05′ E., 1060 m. The species found at Rimini may be also d'Orbigny's *B. ariminensis* d'Orbigny (Am. Sci. Nat., Vol. 7, p. 269, No. 8).

Protoglobobulimina turgida (Bailey)

(Fig. 169)

This species has been studied exhaustively under the name of *Globobulimina turgida* by Höglund (1947, p. 248-249). It has, though it did not occur in my material from the Archipelago, a very high value in respect to its place in the system, and, as the toothplate shows some striking peculiarities which show its systematic place, I give here some details of it, which have been



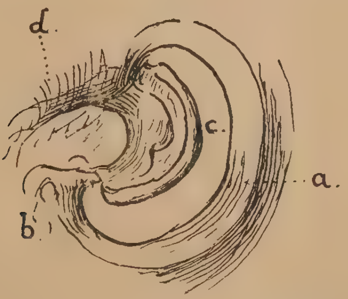


Fig. 169. *Protoglobobulimina turgida,* from the coast of Iceland. m., n. apertures with toothplates; o, aperture seen from the foreside and from above, the same parts are indicated with the same figures; all × 630; p.q., two successive sections through a toothplate with underneath the former aperture with its plate; r, situation of two successive apertures, showing that they form an angle of about 180°; × 480.

neglected by Höglund, found on material Dr. Nørvang kindly sent to me from his collections from the Norwegian coast (SW. of Torsköy, Biol. Stat. Herdla, 350-400 m depth).

The toothplate has not yet the pillar-shape of those of real *Globobulimina.* It has the shape of an open trough, its attached part being broad and somewhat flaring, the free part not very much protruding from the aperture, thin, with a fringed upper border. At the dorsal side of the folded free part the opening of the aperture is found, while at the inner side of the trough one can get likewise into the interior of the chamber, as this inner part is open at its foreside, and runs down toward the upper end of the foregoing toothplate. Thus, when one creeps dorsally from the toothplate into the chamber, one gets into the main part of the chamber, whereas, when one creeps into the hollow of the toothplate, one jumps down into the aperture of the former chamber. It may be, that the protoplasm, streaming straight through the apertures, is of a different structure than that, found in the larger part of each chamber.

Thus, the aperture of this species shows the characteristics of that found in most toothplate-Foraminifera, and does not show the somewhat reduced state, found in real *Globobulimina.* Without doubt the toothplate of real *Globobulimina* has developed from that of *Protoglobobulimina turgida* by reducing the free folded part into a pillar, and by developing the upper end of this pillar into a fan-shaped building. In this way the flaring aperture of *P. turgida* became closed at its lower end, as the free part reduced and the base of this part was attached to the base of the attached part.

In *Protoglobobulimina pupoides,* the toothplate shows the state, found in *Buliminella* and allied forms; in *P. turgida* it looks more like that in some species of *Virgulina,* except for the fact, that the upper part of the plate is free from the upper border of the aperture. In *Globobulimina* the plate has gone in the direction of this development, and has become a pillar, the free part being reduced.

Genus **Globobulimina**

This genus has developed from *Protoglobobulimina* in developing two typical features. In the first place the aperture becomes somewhat terminal, so that a closing suture is found at its base (closed aperture Höglund's); secondly the toothplate is reduced in respect to its basal and attached part, whereas the upper border of it becomes more or less flaring or fan-shaped. Between the larger elongate pores very fine pores, only discernable with high magnification, are intercalated; I do not know, whether these fine pores are real pores, and whether they are primitive or show a new adaptation.

The toothplate in some older forms, which I found in Miocene layers of Holland, is rather simple, forming a straight pillar without the typical fan-shaped upper part. This may be the first beginning of the development of the typical *Globobulimina*-toothplate, and in later forms the fan-shaped end may have been added.

Protoglobobulimina turgida shows a stage of development, in which the toothplate shows the primitive structure of *Virgulina,* but in which the development of the pores, the overlapping of the chambers indicate the structure of typical *Globobulimina.* This may be a link between *Protoglobobulimina* and *Globobulimina* itself. *Protoglobobulimina turgida* may have derived from *Praeglobobulimina spinescens.*

The endform in this row of development seems to be *Globobulimina auriculata,* occurring especially in the North-Atlantic, from which I could study it in the material from the Ingolf-Expedition, as well as in material, kindly sent to me by Dr. Nørvang from Iceland. In this species the closing of the apertural base is so extensive, that even a suture is lacking in well-developed specimens.

Globobulimina elongata (Cushman)
(Figs. 170-172)

Höglund (1947) described a species from the Pacific which he called species b (Bidrag fr. Uppsala, Vol. 26, 1947, p. 245-246). I found the same species in the material, I examined from the Malay Archipelago, at the following stations, always in few specimens:

1° 43′ S., 99° 32′ E., depth 826 fathoms;
2° 17′ S., 99° 56′ E., 613 fathoms;
2° 26′ S., 99° 35′ E., depth 582 fathoms.

I only found megalospheric specimens, the proloculus diameter ranging from 104 up to 420 μ. As is a rule in toothplate-Foraminifera, the size of test increases with the size of proloculus in the megalospheric form. I found following data:

size of test	diameter of proloculus
1,30 mm	420 μ
0,75 mm	220 μ
0,63 mm	180 μ
0,75 mm	180 μ
0,45 mm	104 μ

The species shows all characteristics, mentioned by Höglund, except for the diameter of the proloculus, which in my specimens is smaller.

The typical features are:

Test of medium size, oval in form, greatest diameter about the middle. Chambers overlapping the former ones, but not totally, so that all former chambers remain partly visible, inflated. Walls relatively thick, with distinct oblong pores and very fine ones between, not very hyaline. Sutures depressed, distinct. Aperture of the open kind, the two sutures beneath making a blunt angle. Aperture surrounded by a distinct collar, loop-shaped and rounded, but not glaring. Toothplate straight, with fan-shaped tooth showing a blunt, lobulated upper border. Tooth curved backward and not recurved over the aperture.

When studying recent literature, I found, that the species cannot belong to one of the four recent species, mentioned by Cushman and Parker (1947).

But the species shows the same peculiarities, Cushman has given for the tooth of *Bulimina elongata* (U.S. Nat. Mus. Bull. 71, pt. 2, p. 80, fig. 131) which occurs likewise in the western part of the Pacific. So I am convinced, that *Bulimina elongata* (not d'Orbigny) and our species are identic. This is the more probable, as I found, that d'Orbigny's species *Bulimina pupoides* from Rimini likewise is a *Globobulimina* (*Protoglobobulimina*). In that species, very closely allied to *B. elongata* Cushman, the form of the aperture, the typical straight and plate-like toothplate, and the elongate larger pores, together with the very fine pores between, shows in most details the same characteristics

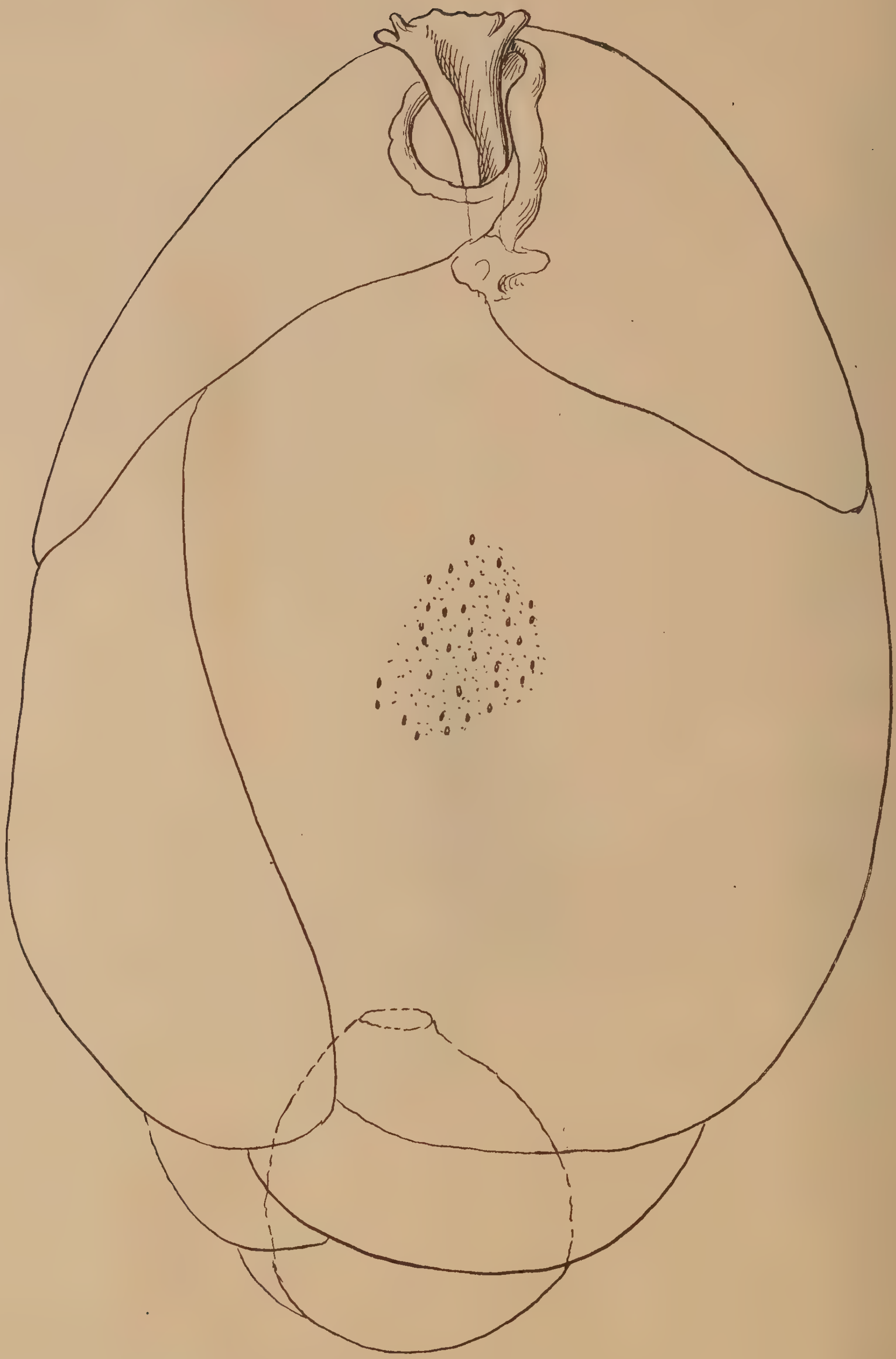


Fig. 170. *Globobulimina elongata.* Megalospheric specimen, showing large, elongated pores and toothplate. × 480.

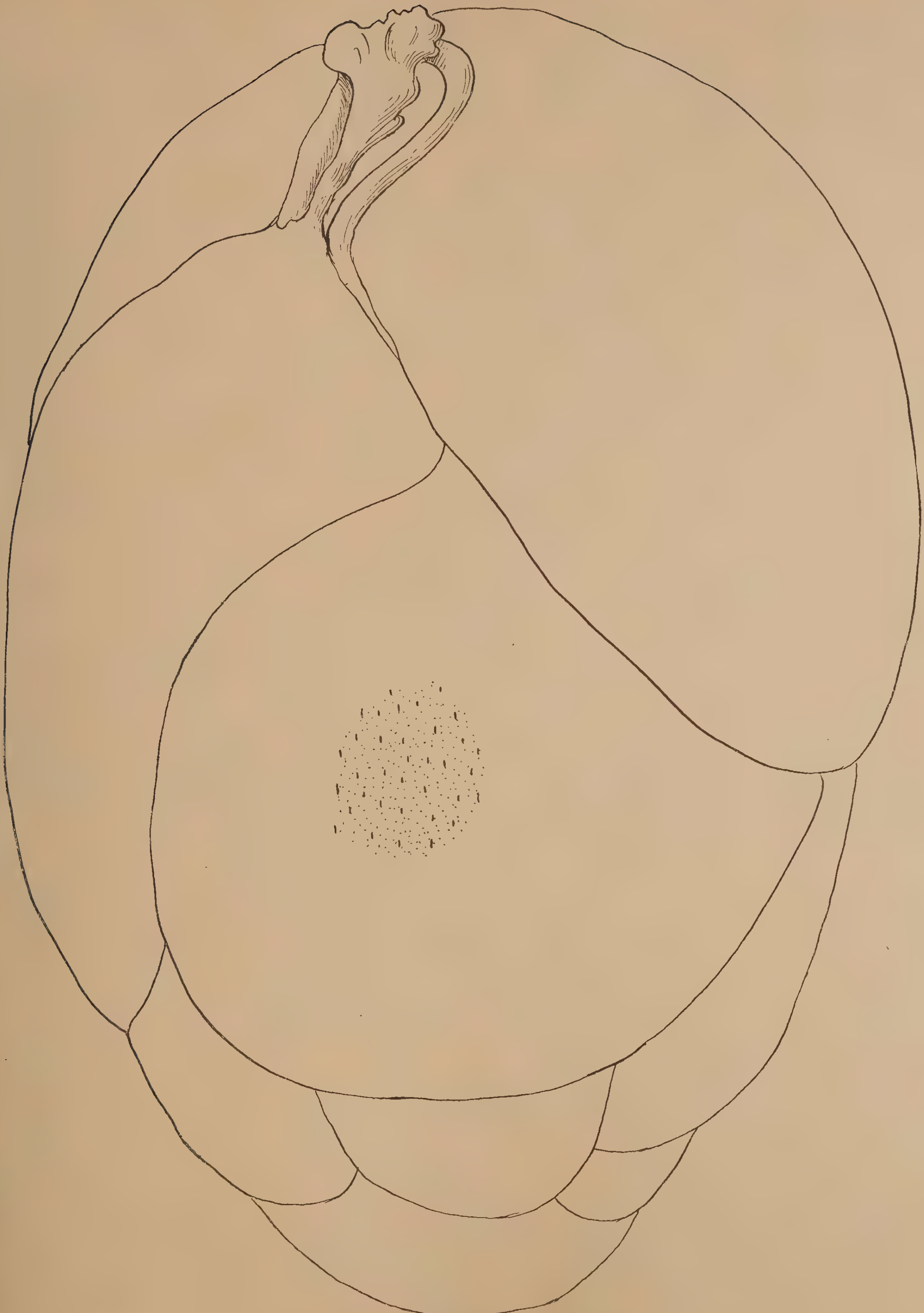


Fig. 171. *Globobulimina elongata. Large megalospheric specimen,* × 480.

as our species, but for the size of the test, the somewhat more overlapping growth of the chambers in *elongata,* the somewhat altered shape of the free part of the toothplate in the latter. Both species, *pupoides* and *elongata,* belong without any doubt to closely allied genera. I found a similar species in the Miocene of the Netherlands, with the same straight and typical simple toothplate; so it seems, that specimens of this type (not-totally overlapping chambers, open aperture, straight toothplate) are in reality primitive ones. At Rimini several primitive species of Foraminifera, more or less identical with Miocene species, are living now.

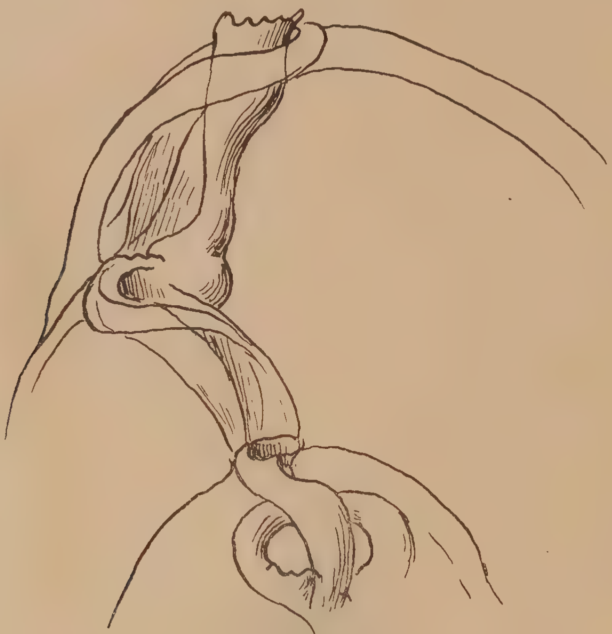


Fig. 172. *Globobulimina elongata.* Toothplates from a section, × 480.

Globobulimina pacifica Cushman

(Fig. 173)

Cushman describes a species of *Globobulimina* from the Pacific as *G. pacifica* Cushman. His description, though scanty, runs:

"Test oval, broadest near the bottom and gradually narrowing toward the apertural end; chambers distinct, the first-formed chamber of the last whorl narrow, usually surrounded on both sides by the last 2 chambers in front view, with only 2 chambers showing in rear view, very slightly inflated; sutures distinct, slightly depressed; wall thin, finely perforate, smooth; aperture loop-shaped, with a slight border and a broad apertural tooth. Length up to 1,50 mm, diam. 1,00 mm. Eastern Pacific." (Cushman and Parker, 1947, pl. 29, fig. 37).

I found only few specimens of this species, all being megalospheric. They occurred as well in gatherings from the Mentawei-Basin (south of Sumatra) as in those south of Flores.

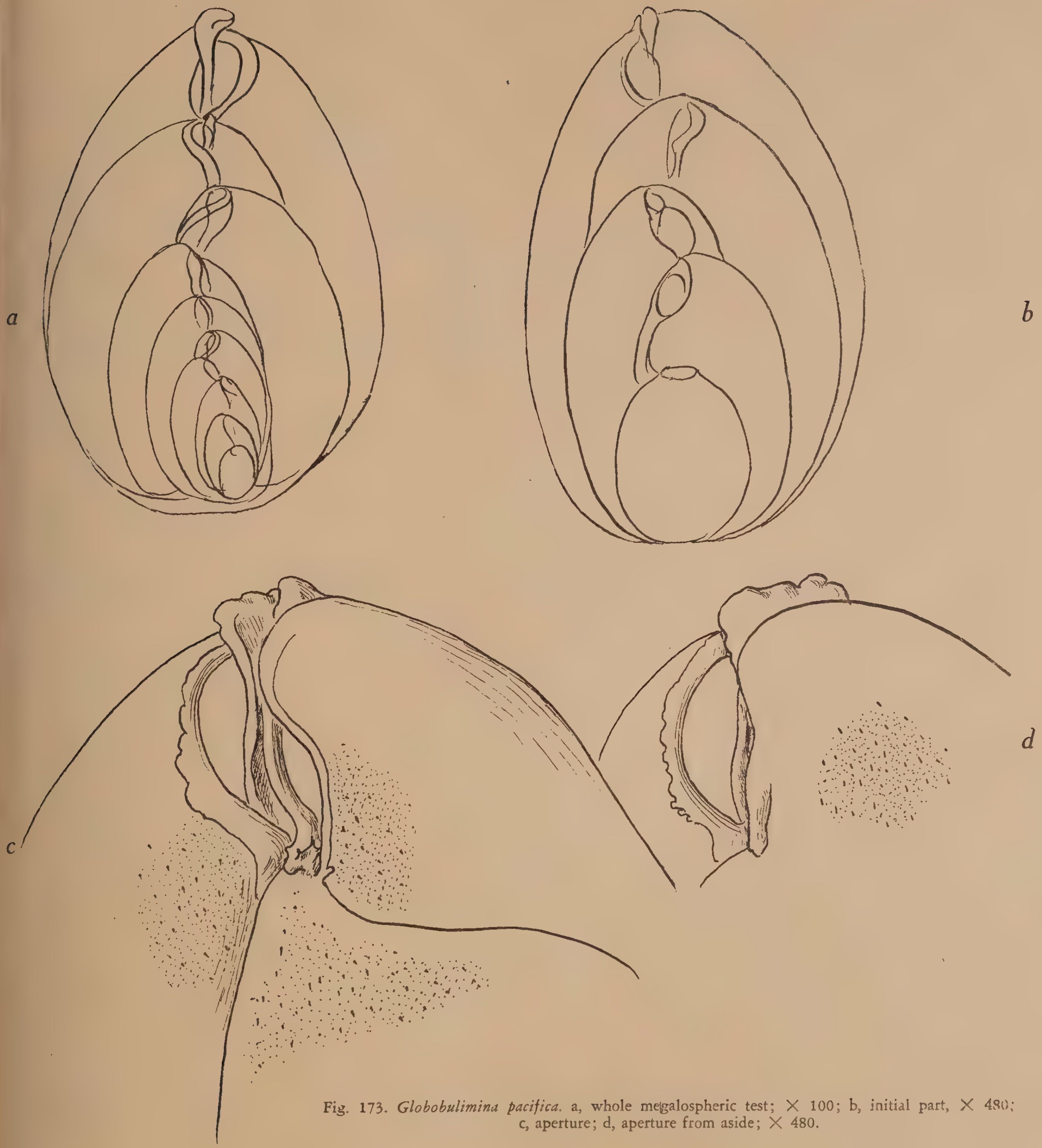


Fig. 173. *Globobulimina pacifica.* a, whole megalospheric test; × 100; b, initial part, × 480; c, aperture; d, aperture from aside; × 480.

We now can describe the species as follows:

Test large, pyriform, broadest near the initial end; chambers overlapping the initial part totally. Walls very thin and smooth, very hyaline, sutures not distinct, not depressed. Pores slightly elongate, with very fine pores between, numerous. Aperture of the open kind, with distinct collar at the side, free from the toothplate, and no collar at all at the attached side. Toothplate slightly curved, folded, forming a pillar ending in a blunt, slightly projecting tooth, with lobulated end-border, slightly turned towards the apertural opening.

So here we have a species, which shows the "primitive" character of toothplate and an open aperture (no closed suture beneath the aperture) together with the developed character of totally overlapped initial part. The fact, that *Globobulimina* must have derived either from *Protoglobobulimina* or from *Praeglobobulimina,* and that both these genera show toothplates which show not the typical pillar-shape, points to the idea, that a *Globobulimina* with totally pillarlike habitus is a highly developed form and not a primitive one. But a Miocene species which I could study, shows as well a very much reduced, pillar-shaped toothplate.

When *Protoglobulimina pupoïdes* is an ancestral form, *Gl. pacifica* must have derived from that species, as it shows both kinds of pores. As *Globobulimina elongata* is not so highly developed (chambers not totally overlapping) it may be that the latter species is the ancestor of *Gl. pacifica.*

The species has not been mentioned by Höglund (1947).

Length up to 1,3 mm, breadth up to 0,07 mm. Diameter of proloculus 70,20 and 55 μ.

Family *Cassidulinidae*

This family is characterised by the opaque walls, the very simple toothplate, forming a partly folded ridge with one side attached to the primitive genera with triserially arranged chambers, later becoming biserial throughout.

In *Cassidella* the shape of the test is that of a *Virgulina,* but with opaque walls. The arrangement of chambers is triserial in the beginning at least. *Virgulinella* and *Candeina* are supposed to be nothing but pelagic offsprings from *Cassidella,* by having the chambers more inflated and their walls thinner, while openings at the sutures are developed, and in *Candeina* the toothplate is reduced in the later chambers of the test. In *Ehrenbergina* on the other hand the test is coiled in the earlier stages; in *Cassidulina* this coiling has reached the whole test. From this genus *Cassidulinoides* is regarded to be an offspring, as the test in this genus once again became partially or totally uncoiled. *Cassidulina islandica* Nørvang, formerly believed to be identical with *C. crassa,* shows the tendency to have much coarser pores, and has a highly developed toothplate. This genus leads in one direction to *Pulleniatina* and *Sphaeroidina,* in which genera the toothplates are mostly reduced.

The toothplates of the *Cassidulinidae* (fig. 174) show in all forms a very typical type of organisation. The prototype of it can be found in *Cassidella tegulata,* in which senonian species it consists in an attached part, creeping over the basal chamberwall from the upper end of the former aperture to the base of the next, and then attached to its border, running upward, while the free part is folded along the upper border of the aperture and then runs down along the opposite border of the aperture. Thus the toothplate forms a nearly closed sacculus, with only an opening between the lower border of the free part and the basal chamberwall.

These features of the primitive toothplate of the *Cassidulinidae* show but little development in the whole family. In some cases the border of the attached part is lobulated or irregularly sawed (*Cassidella oligocenica, Cassidulina laevigata, Cassidulina islandica*); in other instances the free border of the free part is lobulated or sawed (*Cassidella squamosa, Cassidulina tortuosa, Cassidulina subglobosa*), but in most species the borders of the toothplate are smooth throughout (*Cassi-

della complanata, Virgulinella pertusa, Candeina nitida, Ehrenbergina hystrix and *pacifica, Cassidulinoides pupoides*). All those forms thus would not have been distinguished by their toothplates, had not the aperture in its differentiation in every direction given another peculiarity to the structure of the plate. For in *Ehrenbergina* the recurrent direction of the aperture has given rise to a backward folding of the plate, while in *Cassidulina* the short, oval aperture gave rise to a very low toothplate,

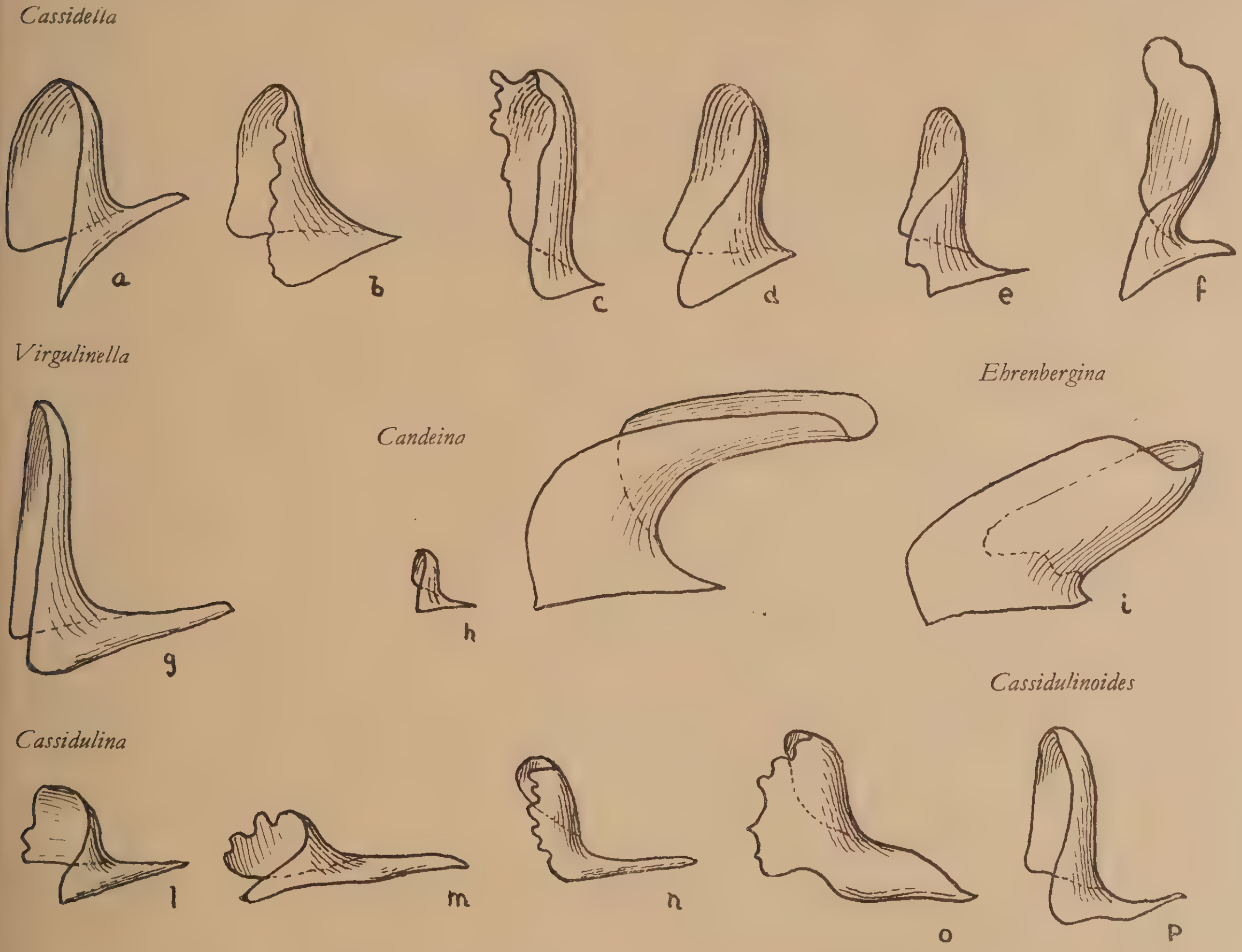
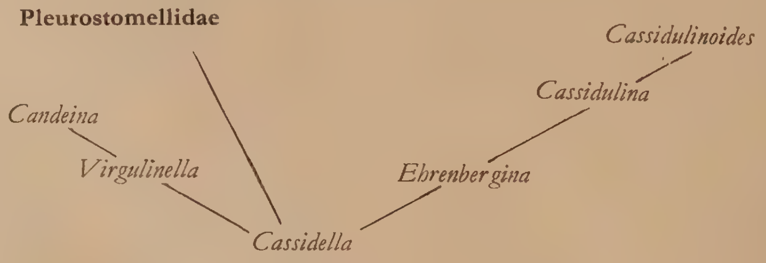


Fig. 174. Toothplates of *Cassidulinidae*. First row: *Cassidella*; a, *C. tegulata* (Senonian); b, *C. oligocenica* (Tertiary); c, *C. squamosa*; d, *C. compressa*; e, *C. pacifica*; f, *C. complanata*. Second row: *Virgulinella, Candeina*; g, *Virgulinella pertusa*; h, *Candeina nitida*. Third row: *Ehrenbergina*; i, *E. hystrix*; k, *E. pacifica*. Fourth row: *Cassidulina*; l, *C. subglobosa*; m, *C. tortuosa* (Tertiary); n, *C. laevigata*; o, *C. islandica*. Fifth row: *Cassidulinoides subsquamosa*.

whereas in *Cassidella squamosa* the closing of the basal part of the aperture makes, that the toothplate is drawn upward. In *Cassidella pacifica* a peculiar hook at the base of the aperture is found.

In all *Cassidulinidae* the toothplate tends to form a kind of bow-net, which makes it impossible for intruders to reach the inner part of the chamber. This may be its main function in this group. It may be that the lack of typical ornamentation, often found in toothplates of other Foraminifera, is caused by this function. In all species, belonging to the *Cassidulinidae* the toothplate shows the same opaque structure which is found in the walls of most of these species too. This is a striking difference with all other groups of toothplate-*Foraminifera,* in which the toothplates are even very hyaline.

Moreover it is very remarkable, that in all known *Cassidulinoides* (*subsquamosa* and *mexicana*) the toothplate is of the primitive kind, found in *Cassidella tegulata,* the ancestral type).



The family of the *Cassidulinidae* and its relations to other families. This scheme has been developed mainly in respect to the development of the toothplates. All groups, related with this family show, in any case in their primitive forms, fine pores and more or less well developed toothplates.

Geographic distribution.

Cassidella:
- *Cass. squamosa:* eastern and western parts.
- *Cass. complanata*: eastern part.
- *Cass. pacifica*: eastern part.

Candeina:
- *Cand. nitida*: western part.

Ehrenbergina:
- *E. hystrix*: eastern part.
- *E. pacifica*: eastern part.

Cassidulina:
- *C. subglobosa:* western and eastern parts.
- *C. laevigata:* western and eastern parts.

Cassidulinoides:
- *C. subquamosa:* eastern and western parts.

Candeina nitida occurred only very rarely in the western part of the Archipelago; all other species of the family of the *Cassidulinidae* were found in the eastern part, some of them in the western too. *C. squamosa* and *C. subsquamosa* are known to occur in the Atlantic region, as well as *Candeina nitida, Cassidulina subglobosa* and *Cassidulina laevigata.* All other species, viz. *Cassidella complanata* and *pacifica, Ehrenbergina hystrix* and *pacifica* are thus typical east-Pacific species.

Genus **Cassidella,** nov. genus

Genotype, *Virgulina* (*Bolivina*) *tegulata* (Reuss).

Description of the genus:

Test in early stages triserial, but soon becoming biserially arranged, especially in the megalospheric forms. Test always elongate, often somewhat twisted. Aperture an oblique loop-shaped or elongated slit standing on the suture of the last chamber, and running up toward the top of the chamber. Toothplate a narrow folded building, always attached to the lower border of the aperture, very simple. Walls always opaque, with very fine pores.

Many species of the genus have been described under the name of *Virgulina,* such as the cretaceous and eocene *Virgulina tegulata* and the miocene *Virgulina schreibersiana,* as described by Ten Dam and Reinhold. Both species, as giving typical characteristics of the new genus, are described anew in this paper. Several recent forms occur also, among which the so-called *Virgulina compressa* is the commonest form. This species was also found in the Pacific material, and has been described in this paper too, though it may be but a variation of the form, described by Ten Dam and Reinhold.

Real *Cassidella* easily can be distinguished from *Virgulina* by the opaque test (*Virgulina* shows always very hyaline tests) and by the toothplate, which in *Virgulina* shows in most cases a well-developed free tooth, while in *Cassidella* the toothplate is opaque and is always very simple, resembling an at one side opened sipho.

The type of the genus is *Cassidella oligocenica* Hofker.

Cassidella tegulata (Reuss)
(Fig. 175)

In the Maastrichtian layers a species occurs which has been called by several authors *Bolivina tegulata* Reuss, but which, when a closer examination is put through, shows to be a real *Cassidella.* I studied several specimens from my collection from the Jekerdal which is very typical Maastrichtian chalk. The species shows a large variation as to its outer form, but internally it shows always the same characteristics. The first part of the test is triserially arranged, the number of triserial rows mounting to 5 in specimens which show a proloculus of about 16 μ diameter. Then biserial chambers are added, mostly 3-5 pairs of them. The aperture is a narrow longitudinal slit with a higher and a more sunken border, the higher one always being the border, directed toward the lower suture of the chamber, and always attached to the typically simple toothplate, characteristic for the genus *Cassidella.* This toothplate originates from the upper border of the former foramen and runs along the basal wall of the chamber, and then upward along the lower border of the next aperture, forming a somewhat folded curtain before that aperture, when seen from the inside. The walls of the test are very finely perforate and show the opaque texture of all cassiduline forms.

The species is known as a *Virgulina* (viz. Cushman, Laboratory Foram. Research, Special Publ. No. 9, 1937, p. 4-5, Pl. 1, figs. 8-12), but the toothplate clearly indicates, that it has nothing to do with that genus.

Length of outgrown specimens 1-1½ mm.

Cassidella oligocenica nov. spec.
(Fig. 176)

Synonyms are:

Virgulina schreibersiana Czjzek (partim).

Virgulina squamosa Egger (not d'Orbigny).

As I have shown, already, my *Virgulina schreibersiana* from the Ammontatura is a real *Virgulina,* and has nothing to do with the species, here dealt with. Ten Dam and Reinhold described it under the name of *Virgulina schreibersiana* Czjzek from the Oligocene of the Netherlands.

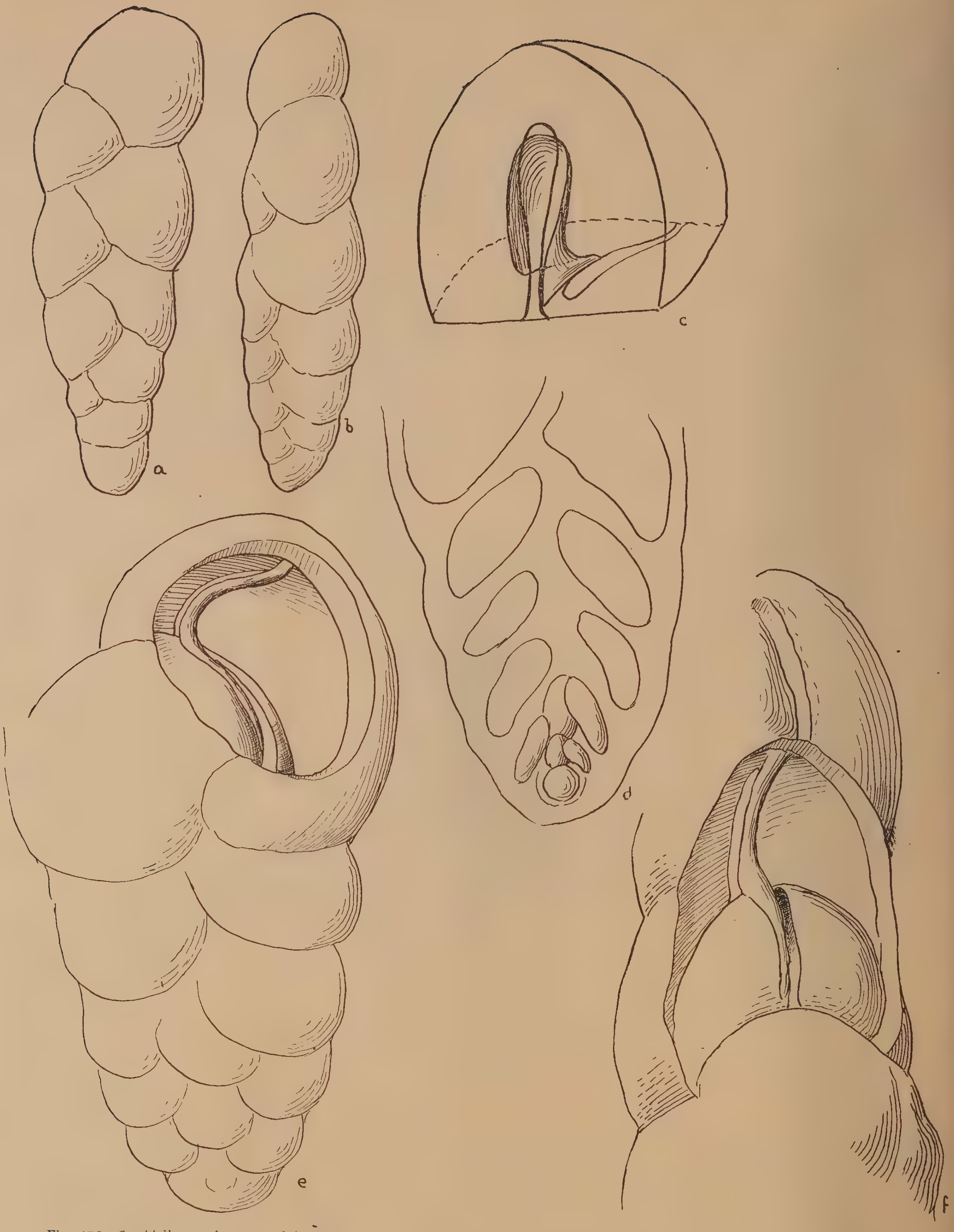


Fig. 175. *Cassidella tegulata.* a and b, specimen from two sides, × 90; c, toothplate in the chamber, reconstructed; d, section of initial part, × 480; e, part of specimen, one of the chambers opened, × 430 f, another specimen with opened chamber, to show the toothplate, × 430.

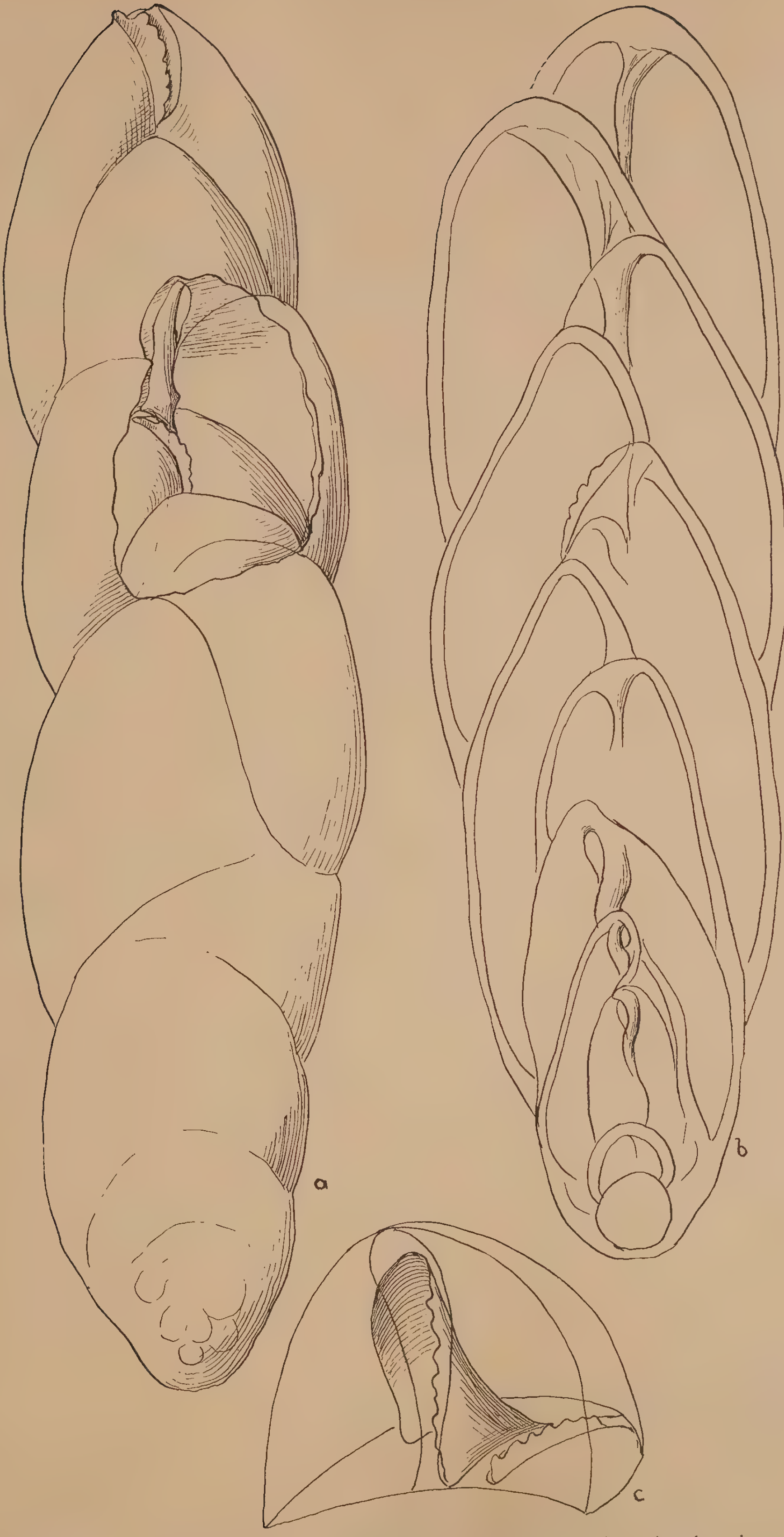


Fig. 176. *Cassidella oligocenica.* a, microspheric with opened chamber; b, section through megalospheric individual; c, schematic figure of toothplate. All × 420.

I got plenty material by the kindness of the Dutch Geological Survey, and came, after a closer examination of the tests to the conclusion, that the species has nothing to do with real *Virgulina,* as the test is not hyaline and the toothplate does not show the characteristics of that of *Virgulina,* but those of *Cassidella.* As I believe that very different species have been gathered under the name of *"Virgulina schreibersiana",* e.g. those described by Cushman (Lab. Foram. Research, special Publ. No. 9, 1937, pl. 2, figs. 11-20) and that most of them do not belong to *Virgulina,* and as the description by Czjzek is not detailed enough to state, whether a specimen belongs to it, or not, I have given a new name to the form, occurring in the Oligocene of the Netherlands, *Cassidella oligocenica.*

Description.

Test elongate, nearly 4 times as long as broad. Chambers in the earlier portion triserially arranged, in the later portion becoming more or less biserially, but never typically. Transverse section slightly compressed or rounded. Test in the A_2-generation biserial, but in the B-generation wholly triserial. Later chambers somewhat inflated, but never clearly; sutures more or less distinct, slightly curved; walls smooth, polished, very finely punctate, opaque throughout. Aperture a slit at one of the sides of the last-formed chamber, running straight upward to the upper margin of the chamber, with its broadest part at the upper end, and with the attached part of the toothplate clearly denticulated or sawed. Toothplate very simple, beginning at the upper end of the former aperture, the attached part running along the base of the chamber toward the sidewall, and then running upward along the border of the aperture, with a sawed endpart. Free part of the toothplate forming a kind of gutter situated before the aperture, when seen from the inside. Free border not visible from the outside. All three generations occur, that with a proloculus of about 10 μ diameter (B-form) with a length of test of about 1 mm, very slender, with numerous chambers, the later ones somewhat inflated; that of a diameter of the proloculus about 30 μ, less slender, with a length of about 0,50 mm (A_1), whereas those forms with a proloculus with diameter of about 45 μ attain a length of about 0,40 mm, and show very inflated, biserially arranged chambers (A_2). The three forms always occur together in the samples of the Oligocene, and obviously belong to one species, as they all show the typical dentate toothplate.

I describe here this species fully, as in the first place it gives a striking instance of the genus *Cassidella,* and as recent species, occurring in the Pacific, are, though closely allied to it, belonging to a different species in regard to their toothplates. Cushman (l.c., p. 14) says, that his *"Virgulina schreibersiana"* occurs as well in recent oceans. I am certain now, that the *"Virgulina schreibersiana"* of Ten Dam and Reinhold, now described anew under the name of *Cassidella oligocenica,* has nothing to do with recent species, as will be shown later on.

All so-called species of *Virgulina* have to be restudied again in regard to the structure of the shellwalls (hyaline or opaque) as well as to the shape of their toothplates. Then it will be shown, that several species belong to *Cassidella,* while other species are real *Virgulina.* Some of them, however, are belonging to quite a different genus, *Cassidulinoides.*

Cassidella squamosa (d'Orbigny)
(Figs. 177-178)

This small *Cassidella* was hitherto known as *Virgulina squamosa.* There is much confusion in literature, and yet it is easily distinguishable. Many references to this species may in reality refer

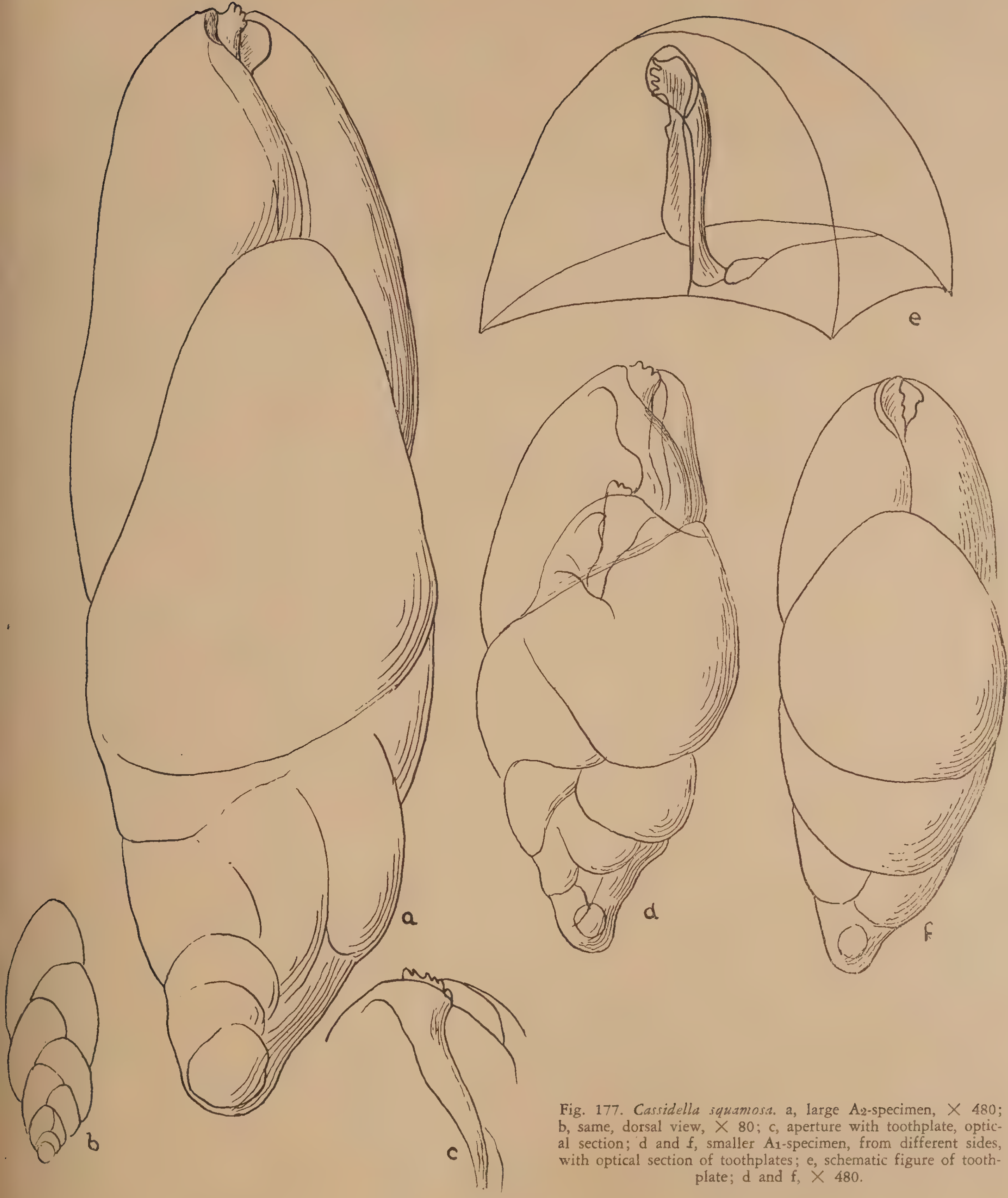


Fig. 177. *Cassidella squamosa.* a, large A_2-specimen, × 480; b, same, dorsal view, × 80; c, aperture with toothplate, optical section; d and f, smaller A_1-specimen, from different sides, with optical section of toothplates; e, schematic figure of toothplate; d and f, × 480.

to quite different species. Nor am I very certain, whether the species, described here, is identical with d'Orbigny's species. I refer only to the somewhat superficial description Cushman has

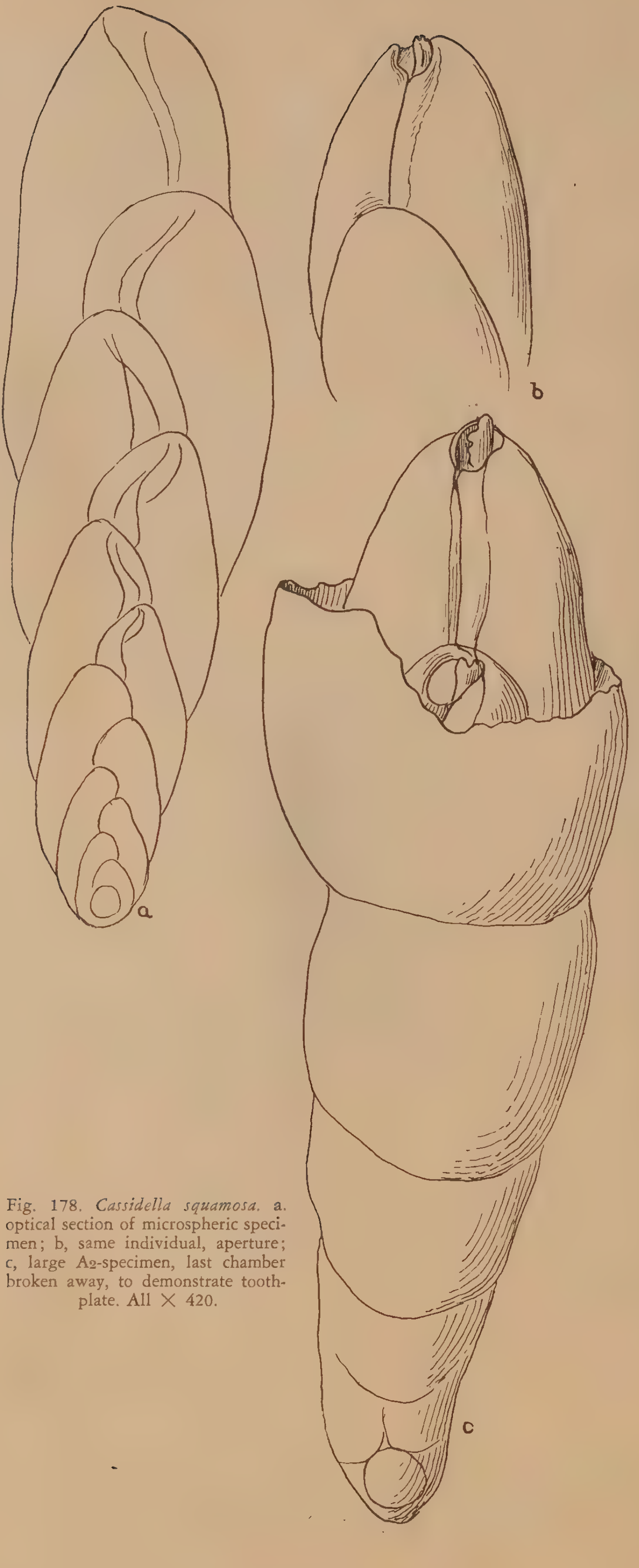


Fig. 178. *Cassidella squamosa.* a. optical section of microspheric specimen; b, same individual, aperture; c, large A_2-specimen, last chamber broken away, to demonstrate toothplate. All × 420.

given (U.S. Nat. Mus., Bull. 71, pt. 2, 1911, p. 91-92) where he says, that the aperture is comma-shaped. That is a remarkable feature of this species, as in reality the aperture is closed but for the upper part, so that, seen from above, it is comma-shaped.

I will first give the description of the species.

Test elongate, in some forms up to 3½ times as long as broad. Chambers slightly inflated, high. Walls smooth, very finely punctate, opaque. In all three generations the test begins triserially, and then becomes sooner or later somewhat biserially arranged. Aperture standing on the suture, but closed, forming a suture, for nearly $^{2}/_{3}$ of its length, then opened at the end of the chamber. Toothplate of the usual simple type, but elongate at it runs towards the opened part of the aperture from the former one, attached to the closed suture of the aperture, with a folded free part which ends into a somewhat protruding tooth, the end of which always is finely denticulated. The closed aperture, together with the denticulated tooth are very typical characteristics for the species. It is always small, the largest shells being that of generation A_2, measuring up to 0,45 mm; B-shells are mostly smaller, up to 0,30 mm.

The somewhat more differentiated toothplate begins to lead to that of real *Virgulina,* but its opaque structure, together with that of the shellwall, points without doubt to *Cassidella.*

I will not refer to other localities, but for those, found by myself, as I am not certain, that other authors dealt with the same species. Cushman in his work on the Albatross-Foraminifera (U.S. Nat. Mus., Bull. 161, 1942) does not figure or mention specimens with this remarkable aperture.

I found it at the following stations:
266.5° 56′ S., 132° 47′ E., depth 595 m;
2° 34′ S., 99° 44′ E., 777 fathoms;
2° 26′ S., 99° 35′ E., 582 fathoms.

So it seems to occur in both regions of the Archipelago.

Cassidella complanata (Egger)

(Figs. 179, 180)

With some hesitation I reckon some specimens, found at St. 10° S., 123° E., depth 453 fathoms, to this species. The specimens resembled much fig. 5, pl. 4, of Cushman's work on Pacific Foraminifera (U.S. Nat. Mus. Bull. 161. 1942). But those, mentioned to belong to the same species, in that plate, show not at all the characteristics. So I have some doubt.

The tests are stout and elongate, much compressed, in the early part twisted, later on biserial. Chambers somewhat inflated. Walls smooth and opaque, with fine pores throughout. Aperture a slit at the upper end of the chamber, closed at its sutural base, but not, as in *Cassidella squamosa,* rounded in its opened part, but slit-like. The proloculus is terminal, and was megalospheric in all specimens found. The toothplate is simple, running from the side of the former aperture along the basal wall of the chamber, and then turning upward along the side of the next aperture, with a folded part, from which the upper end is found somewhat protruding from the aperture, but this end is smooth, and not denticulated as in *C. squamosa.* Length of tests up to 0,8 mm, larger breadth 0,20 mm, smaller breadth 0,12 mm.

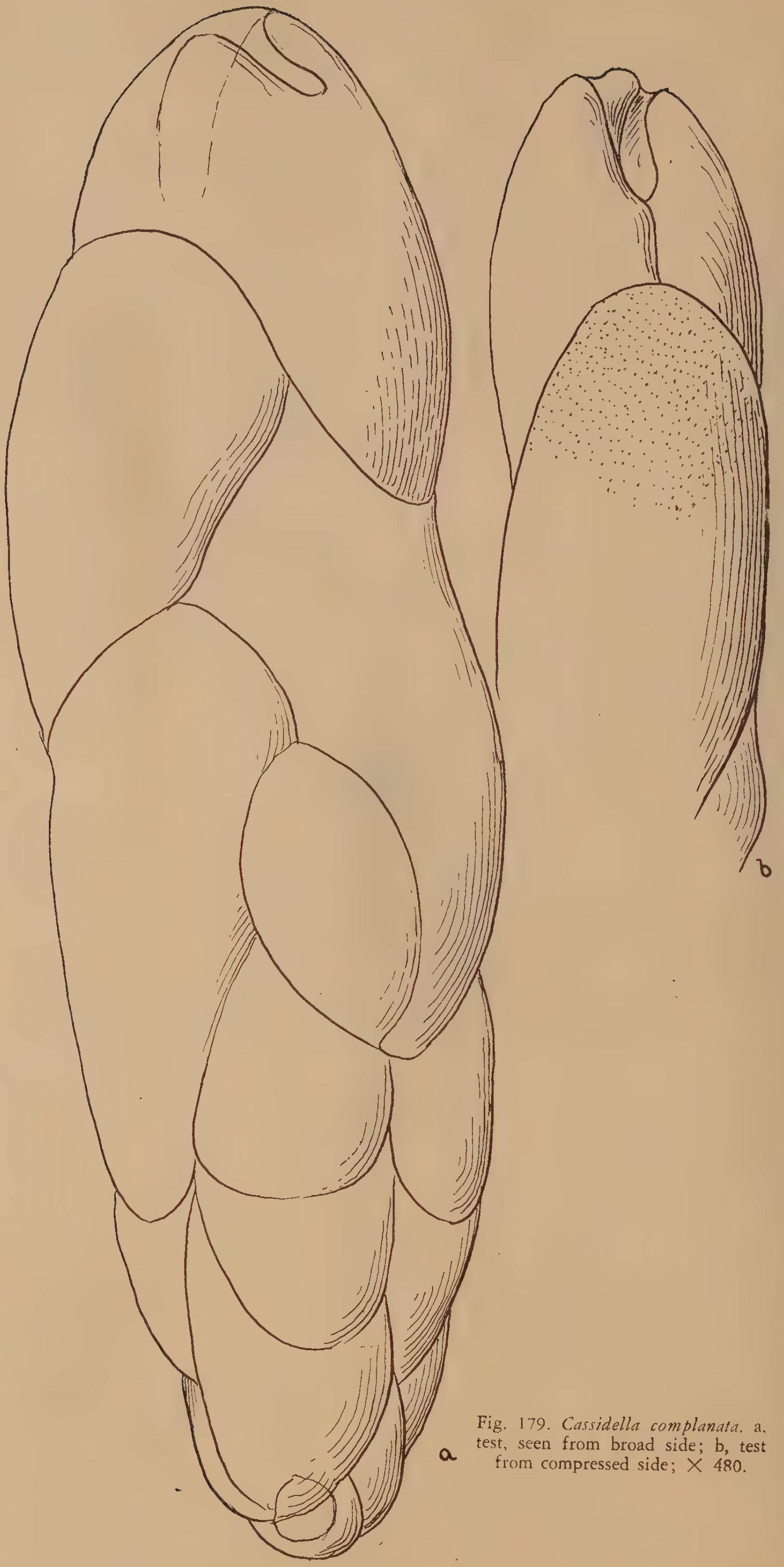


Fig. 179. *Cassidella complanata.* a, test, seen from broad side; b, test from compressed side; × 480.

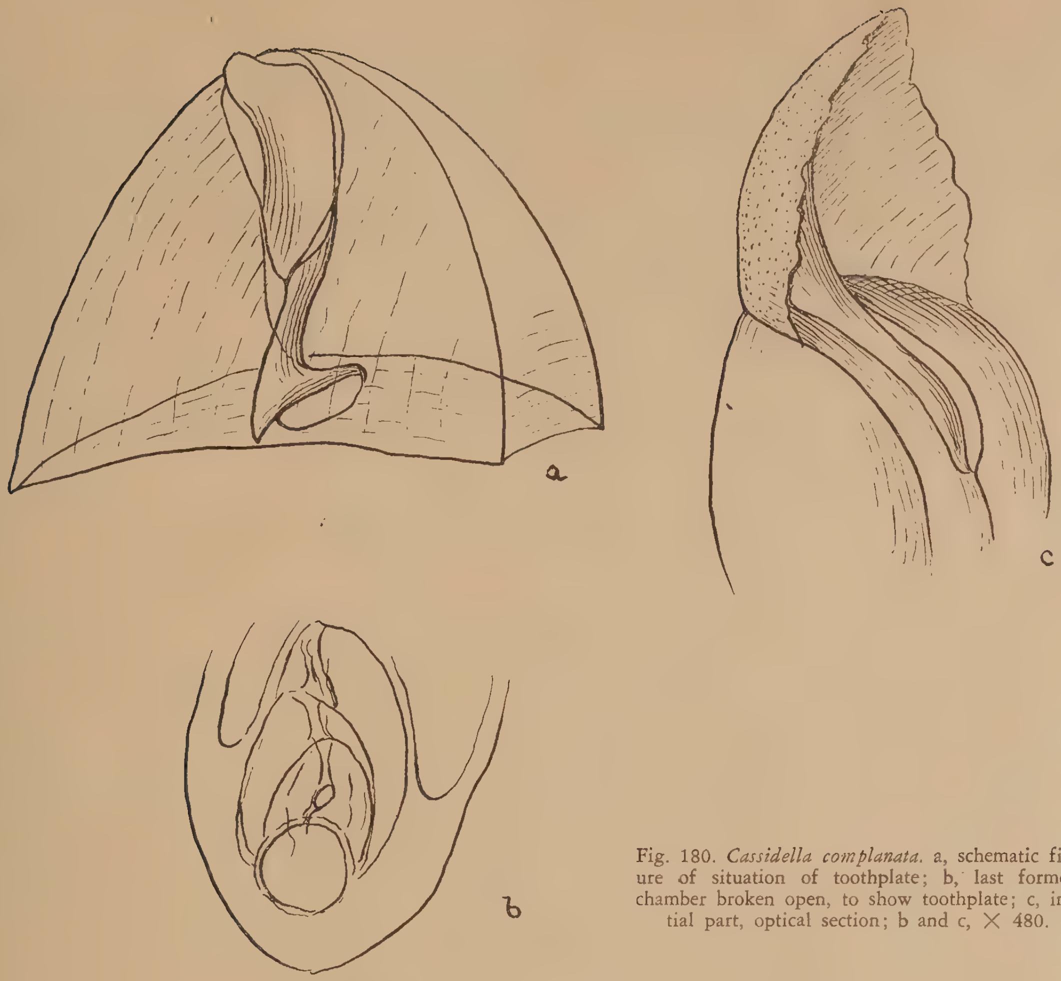


Fig. 180. *Cassidella complanata.* a, schematic figure of situation of toothplate; b, last formed chamber broken open, to show toothplate; c, initial part, optical section; b and c, × 480.

Cassidella pacifica nov. spec.

(Fig. 181)

This species is identical with those, figured by Cushman on pl. 4, figs. 2-4, U.S. Nat. Mus., Bull. 161, pt. 3, 1942, and Lab. Foram. Research, spec. publ., No. 9, 1937, pl. 4, figs. 14, 15, 17, and mentioned together with quite a different species, *Virgulina complanata* Egger. It is not clear, whether Egger met with the same species, since his descriptions and figures are not detailed enough. So I have called the species by a new name, *Cassidella pacifica.* It shows all characteristics of the genus *Cassidella,* with its opaque walls, and its simple toothplate. The difference with the other mentioned species lies in the apical spine and the aperture, which is an open aperture, placed with its broad base on the suture, while in most other mentioned species the aperture is closed at its base. The toothplate is of the simple type, with its free border protruding from the aperture, which border shows at its lower end a slight hook, while it is smooth, not denticulate.

As Cushman mentions already, it seems to be a very rare species, as it occurred only in a single specimen at St. 213, at Saleyer-anchorage, between coral-reefs.

Genus **Pleurostomellina**

This genus clearly shows, that the more initially placed chambers are much like those of *Cassidella,* whereas the later chambers differ from that genus in a unilocular arrangement. This view is in full agreement with the form of the toothplate; in initial chambers the toothplate is not distinguishable from that of *Cassidella,* whereas in the uniserial part the plate shows a freed attached part, as in the uniserial parts of *Loxostoma* and *Rectobolivina.* Moreover the opaqueness of the walls and the fine pores point too to *Cassidella.*

As one knows, Silvestri has created many genera, all belonging to the *Pleurostomellidae*; I am convinced, after a study of literature, that all these genera show only specific differences; this is the more probable, as very few species belong to each of Silvestri's genera.

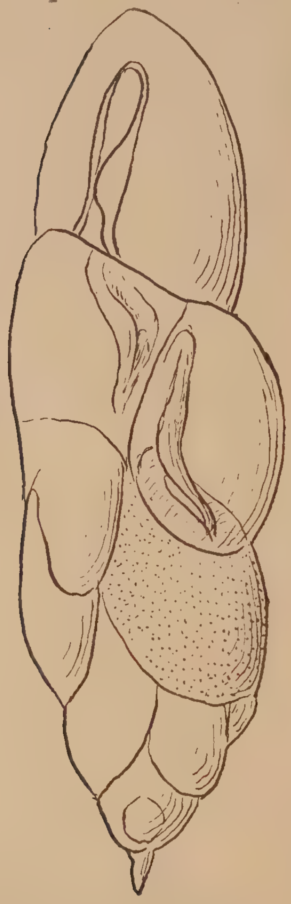


Fig. 181. *Cassidella pacifica* nov. spec. Test, showing toothplates in optical section and the fine pores. × 480.

Pleurostomellina alternans Schwager
(Fig. 182-185)

This species seems to be a very rare one in recent seas; it has not been found in my material; but it has been mentioned by various authors, by Cushman from Mindanao. It may be, that those recent records are from sub-fossil specimens.

I found it however in larger quantities in samples, kindly given to me for investigation by the Geological Survey of the Netherlands, from localities, especially in boring 0, depth 260-265 m, obviously from Lower Cretaceous strata. This fossil form does not differ in any characteristic from those, described from recent localities. There seems to have been only a single species, all throughout the ages, which has not altered whatever.

From recent and fossil localities, cretaceous and tertiary, mostly two "species" have been recorded. Often these two species occur in the same sample, e.g. Cushman, U.S. Nat. Mus., Bull. 100, p. 138-139, where both so-called species occurred in St. D5236. They have been called *P. alternans* Schwager and *P. subnodosa* (Reuss).

I also found these two species together, in many specimens, in a sample from boring 0, so that there is no doubt, that recent and fossil records of these two species are dealing with only a single one, as the only difference between both forms is the size of the proloculus, and consequently the bluntness of the initial part. Cushman's species *P. acuminata,* established on a single specimen(!) is nothing but a B-form, as this form often builds a short spine at the initial end.

When we compare the descriptions, given of the three "species" hitherto known, we find, that there are no real differences between them, except for the initial part. But the latter is due only to the different size of the proloculus in the three generations.

Statistical investigations on the fossil material showed me, that three forms can be distinguished.

B-generation. Proloculus 6-8 μ, followed by 4-6 biserial sets of chambers, and afterwards followed by 4-6 uniserial ones. Length 1,3—1,7 mm. Last-formed chamber in sideview somewhat pointed at the end, test slightly compressed. Initial end pointed (*P. acuminata* Cushman).

A1-generation. Proloculus 8-12 μ diameter, followed by 3-5 biserial sets of chambers, uniserial ones 3-5 in number. Length 1,4—1,8 mm. Last-formed chamber in sideview somewhat pointed at the end, test slightly compressed, especially in the biserial part. Initial end bluntly pointed or somewhat rounded (*P. alternans* Schwager).

A2-generation. Proloculus 70-95 μ diameter, followed by only uniserial chambers, 4-6 in number. Length 1,0—1,5 mm. Last-formed chamber in sideview often somewhat rounded, test not compressed, with rounded transverse section, as the biserial part is lacking, so that the test has the rounded transverse section from the large proloculus. Initial end globularly rounded, as it is formed by the large proloculus (*P. subnodosa* (Reuss)).

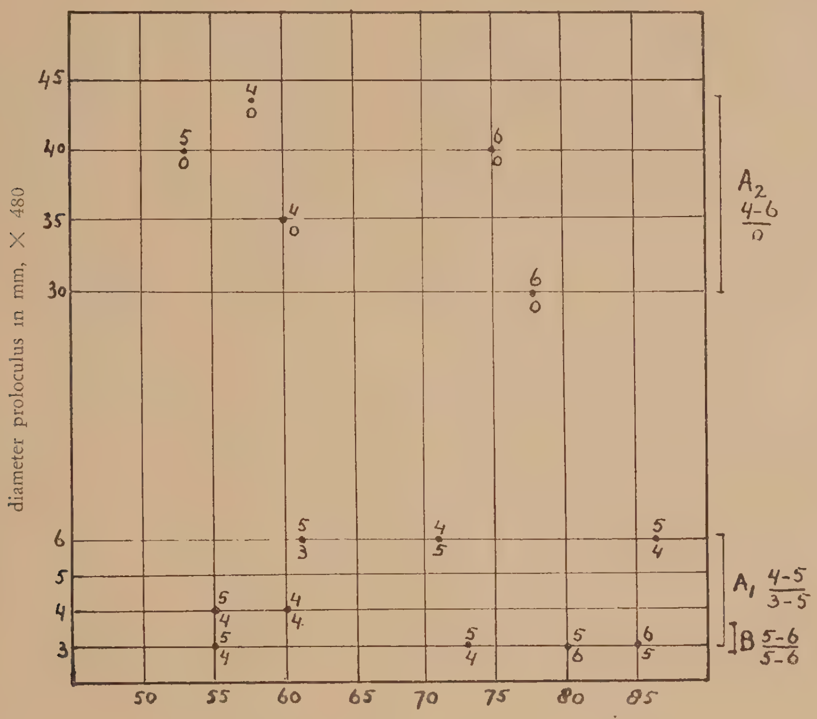


Fig. 182. *Pleurostomellina alternans*. Diagram, showing relation between size of proloculus and length of test, figures above indicate number of uniserial chambers, those beneath the number of series of biserial chambers. By means of those numbers the groups A2, A1 and B can be distinguished.

As it has been pointed out already by several authors, tests of *Pleurostomella* never become really uniserial, as the alternation of the back-side of each chamber is continued all over the test. So I call those chambers uniserial, which show a partially uncovered apertural side.

Many authors have stated the occurrence of an internal "tube" at the aperture, running through each chamber. As this "tube" is nothing but a real toothplate, I have studied it with special care.

When dealing with *Bolivina* and *Loxostoma*, Höglund and I have come to the conclusion, that in *Bolivina* the toothplate shows an attached part and a free folded one, while in *Loxostoma* the attached part becomes free from the wall of the chamber, running straight toward the next aperture. In *Rectobolivina,* with its uniserial chambers, the toothplate in those latter chambers becomes a symmetrically built plate, with both sides slightly folded.

In the genera, allied to *Cassidella,* the toothplate remains very simple, creeping with its attached part along the basal chamberwall, and then forming with its free part a curtain before the aperture, and attached to the distal part of the aperture itself. This pattern is found too in all genera, allied to *Bulimina* and *Bolivina.*

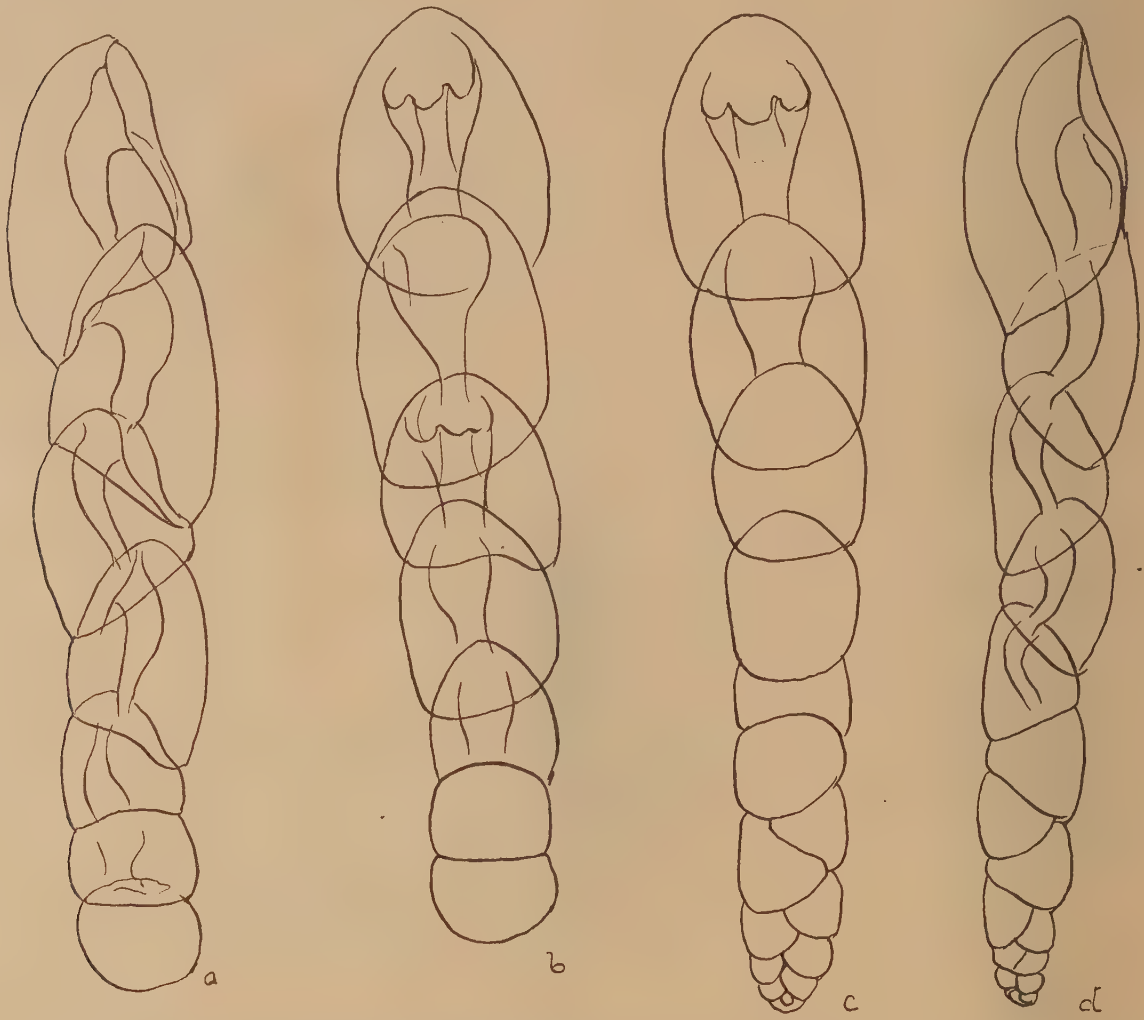


Fig. 183. *Pleurostomellina alternans.* Specimens from a sample from the Lower Cretaceous. a, frontview; b, sideview of an A_2-specimen; c, and d, same views of a microspheric specimen; × 120.

In *Pleurostomellina* the aperture of the biserial chambers is somewhat loop-shaped, and the toothplate shows the structure of that of *Cassidella.* When the chambers get their uniserial arrangement, the attached part of the toothplate becomes free, and the plate itself gradually gets a symmetrical structure. It runs slightly curved toward the next aperture, both sides of it distinctly folded. The free borders of the folded sides are attached to the proximal border of the aperture, forming in many species two distinct points at this side, projecting from the apertural border. The dorsal side of the toothplate is attached, as in *Cassidella* and its allies, to the proximal border of the aperture, forming this border and gradually melting together with it. The pores of *Pleurostomellina* are very fine, and very regularly distributed over the surface of the walls. This is also the case in *Cassidella, Cassidulina,* etc.

Thus we come to the following conclusions as to the relation of *Cassidella* and *Pleurostomellina.*

There are not, as has been suggested, three recent species of *Pleurostomellina* with uniserial endchambers (*Pleurostomellina* Schubert) but only a single one. As the microspheric generation of this species has been called *Pleurostomella* (*Pleurostomellina*) *alternans,* the species has to be called *Pleurostomellina alternans* (Schwager). This species is now known from the Lower Cretaceous upward unto recent times.

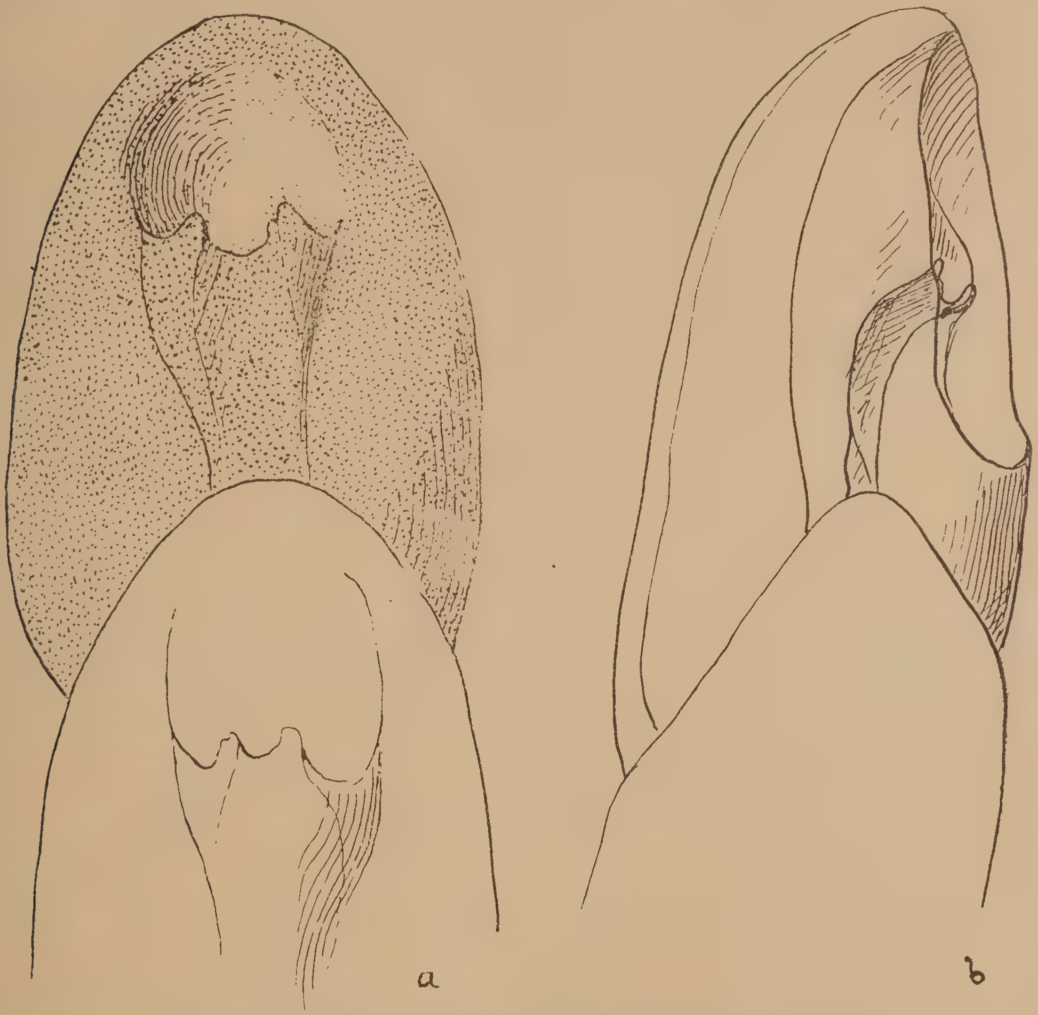


Fig. 184. *Pleurostomellina alternans.* a, last-formed chambers, apertural view of the last-formed one, inner wall of aperture without pores; b, sideview of same specimen. × 630.

The genus *Pleurostomellina* is nothing but a *Cassidella,* in which the chambers have become uniserially arranged; as in other genera, in which uniserial chambers from a biserially arranged initial part have been developed, the aperture has become symmetrical, and the toothplate has become a totally free one. It has been developed from biserial ancestors, may be *Cassidella.* This is clearly stated by the alternating arrangement of the toothplate in the uniserial chambers.

As in *Cassidella,* the toothplate is a simple one and the walls have fine pores, while they are of opaque structure. It is now stated that the genus *Pleurostomellina* is found in the Lower Cretaceous, the Upper Cretaceous, the Paleocene (Ten Dam) and recent times.

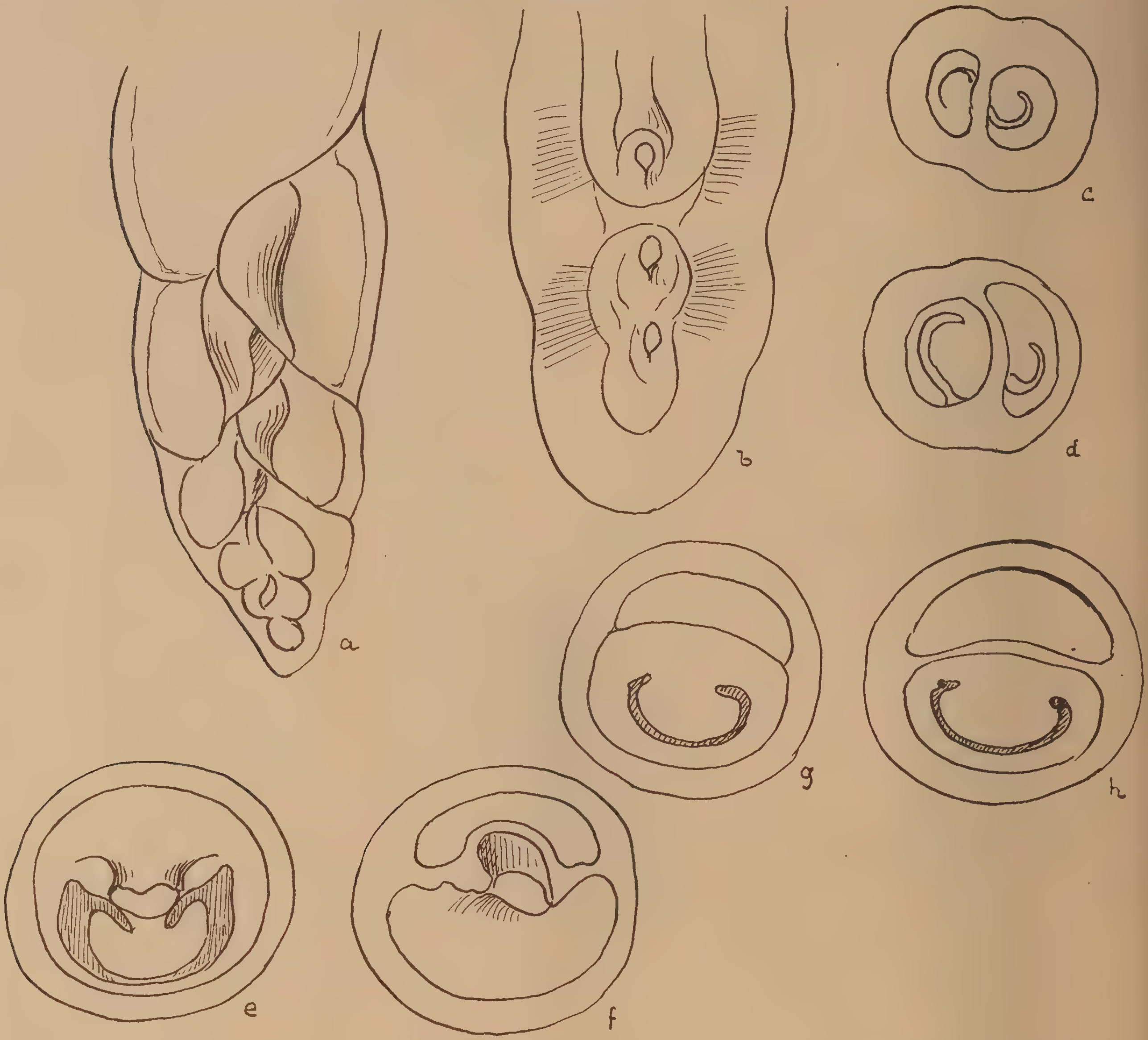


Fig. 185. *Pleurostomellina alternans.* a, section through microspheric initial part, with toothplates as in *Cassidella;* × 480; b, section showing loop-shaped first foramina, × 630; c, and d, transverse sections through first-formed chambers, showing tooth plates as in *Cassidella;* e, toothplate of uniserial chamber, upper part, showing its relation with the teeth of mouth, with next aperture and base of its plate; f.g.h. sections with toothplates; × 480.

Genus **Ehrenbergina**

This genus is very closely related to *Cassidella* and to its offspring *Cassidulina.* In microspheric specimens the test begins with a very short triserial part which soon becomes biserial, as in *Cassidella.* In megalospheric forms the test is biserial throughout.

The first part of the test is coiled up, later chambers form a more or less straight row of biserial chambers. At the dorsal side the chambers alternate, as in *Cassidulina,* but at the ventral side they meet, and often form here a spinous ridge, especially in the recent forms.

The testwalls are always opaque, as in *Cassidella,* but the aperture is different. In *Ehrenbergina* the aperture is always an elongate slit, beginning at the ventral suture of the chamber, but never in the middle of it, always at one of the edges of the chamber, running very obliquely upward parallel to the upper margin of the chamber, and not near to the ventral suture. Several species, hitherto thought to belong to *Cassidulina,* in reality are *Ehrenbergina,* such as the Eocene species *constellata, arenasensis, crispula* and *havanensis.*

In *Ehrenbergina* the toothplate is somewhat more developed than in *Cassidella.* Here too it is folded, and simple, but, as the aperture in reality is lengthened, the plate is much more broadened, and forms with its attached part a protruding hyaline tooth at the ventral side of the aperture. The free part is of the same simple shape as in *Cassidella,* never forming a free tooth at the aperture itself, but only a kind of gutter, running toward the next aperture, and beginning at the end of the former one. The attached part creeps up along the basal wall of the chamber onto the base of the next aperture.

Ehrenbergina hystrix Brady
(Figs. 186, 187)

A single specimen was found at St. 260,5° 53′ S., 132° 48′ E., depth 90 m. Two other specimens were found at St. 49^{a}, 8° 23′ S., 119° 4′ E., depth 69 m.; it seems to be a species

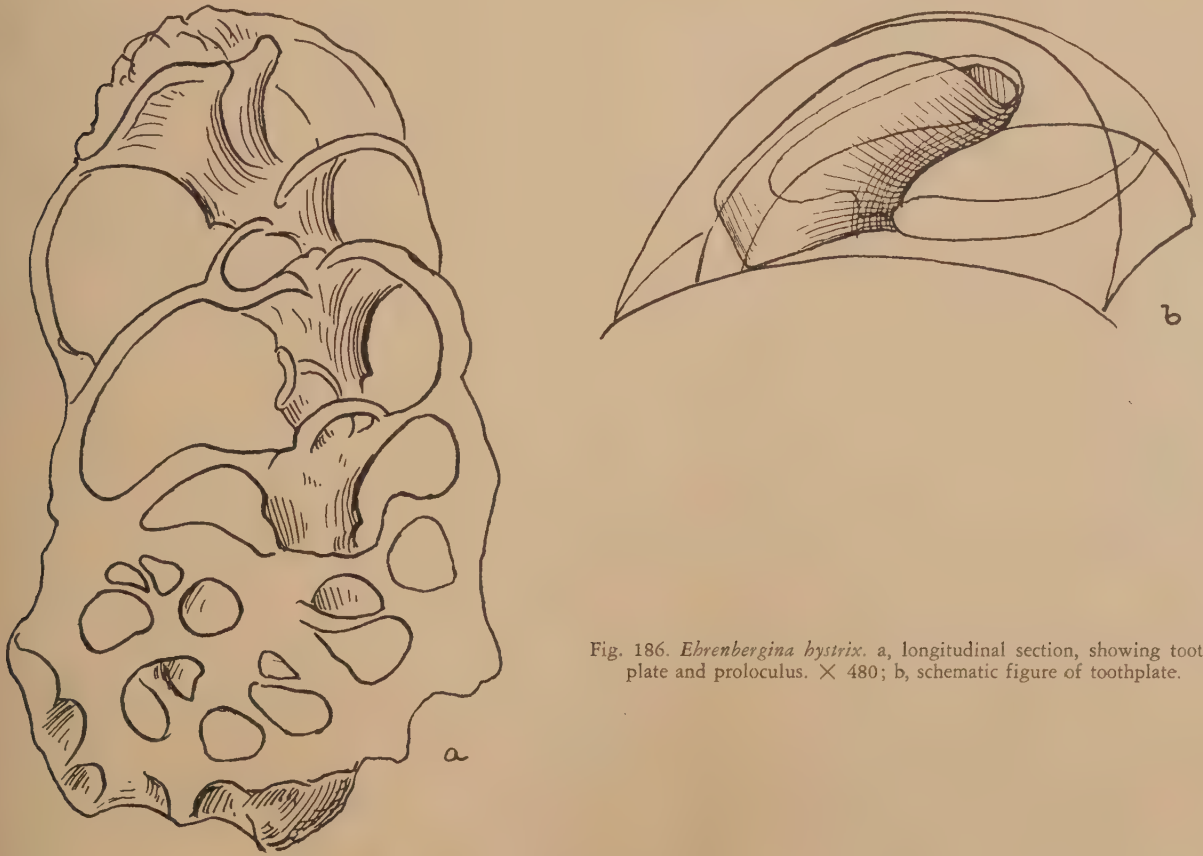


Fig. 186. *Ehrenbergina hystrix.* a, longitudinal section, showing toothplate and proloculus. × 480; b, schematic figure of toothplate.

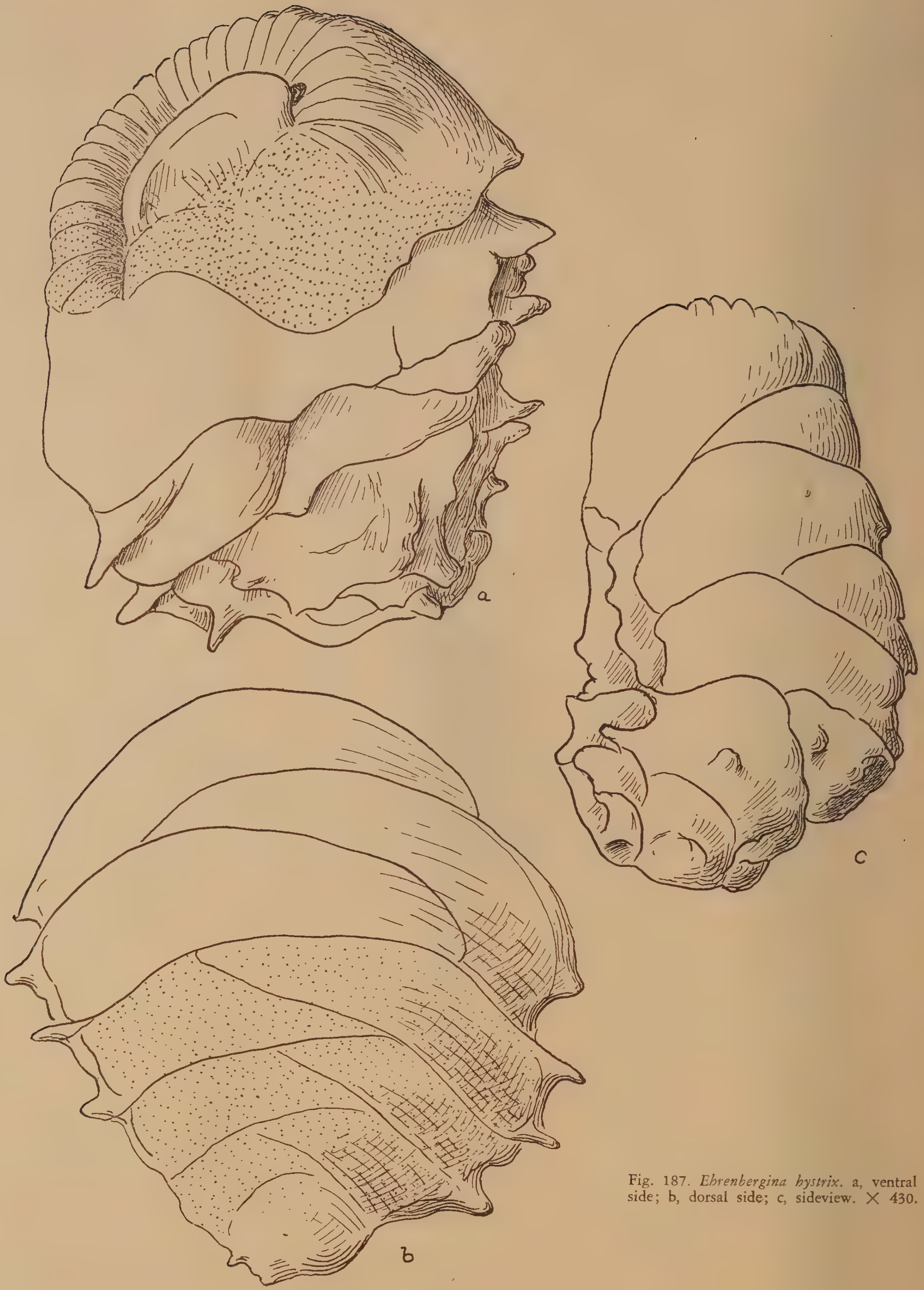


Fig. 187. *Ehrenbergina hystrix.* a, ventral side; b, dorsal side; c, sideview. × 430.

of shallow waters. It was recognisable by its radiate zone around the aperture, the large, protruding toothplate at one side of the aperture, the hyaline last-formed chambers, the hyaline wings between the spines. A section showed it to be of A1-generation, with a proloculus of 17 μ diameter, followed by 8 sets of biserial chambers. The highly developed toothplate in the chambers distinguished it from *E. pacifica,* in which the toothplate is more reduced. At its base it shows a distinct hook, and the free side of it is folded. It is attached to one of the sides of the former aperture, and its rounded tooth is projecting from the aperture of the next chamber. The test is much depressed. The length was 0,25 mm. The characteristics of the species seems to be its compact form, the broad and low chambers, the irregularly placed and short spines, and the typical radiating furrows on the apertural face which are never lacking. These furrows are reminding of those of some species of *Buliminella,* and, as in *Buliminella,* the wall at these furrows shows no pores; it thus is obvious, that this part of the apertural face is formed by the attached border of the toothplate, as in *Buliminella.* This is a remarkable fact which leads to the conclusion, that *Ehrenbergina* is related to *Buliminella* as well.

Ehrenbergina pacifica Cushman
(Figs. 188-195)

Two specimens, both of megalospheric form, were found in a gathering 3° 15′ S., 118° 56′ E. from a depth of 340 fathoms. They showed the large stout spines, characteristic of this species.

One of these specimens was sectioned transversely, the other longitudinally, to be able to study the inner structure of the shell.

In both the initial end was formed by five chambers not including the proloculus. This proloculus in one of them showed a diameter of 41 μ, and was situated at the roof-shaped side of the shell. Underneath (more apically situated) this proloculus a second chamber was found, and two of them more to the apertural face of the shell, thus forming three chambers following the proloculus, suggesting the beginning of a triserial arrangement. Then a second layer of three chambers forms the next row, these too in the same direction, somewhat transversely to the later axis of the shell. Then the biserial chambers follow, in total 4 rows of them.

The other specimen showed an equally blunt apical end, with a proloculus of 27 μ diameter. This proloculus was followed by three chambers situated in a row with its axis transversely to the later axis, while next chambers formed a second triserial row. Then the biserial arrangement began, with a total of 5 rows.

Each chamber is divided into two parts, a central one and a marginal one, separated incompletely by a septum, formed by a typical toothplate. The tooth of this plate is adhering to one of the sides of the aperture of a chamber, and runs down to form a diaphragm towards the opposite side of the former aperture or septal foramen.

Thus the genus points towards the genus *Cassidella,* not only because of the toothplate and its structure, but also because of the typical arrangement of the first sets of chambers, which in the genus *Cassidella* are triserially arranged at first.

Many other specimens were found in the gathering 10° S., 123° 19′ E., from 453 fathoms. They were sectioned in another way, viz. through the median plane. In this way the typical structure of the shell, resembling that of *Cassidella,* was very *clearly* shown. Most specimens were once more megalospheric, but it could easily be observed, that the smaller shells showed the larger pro-

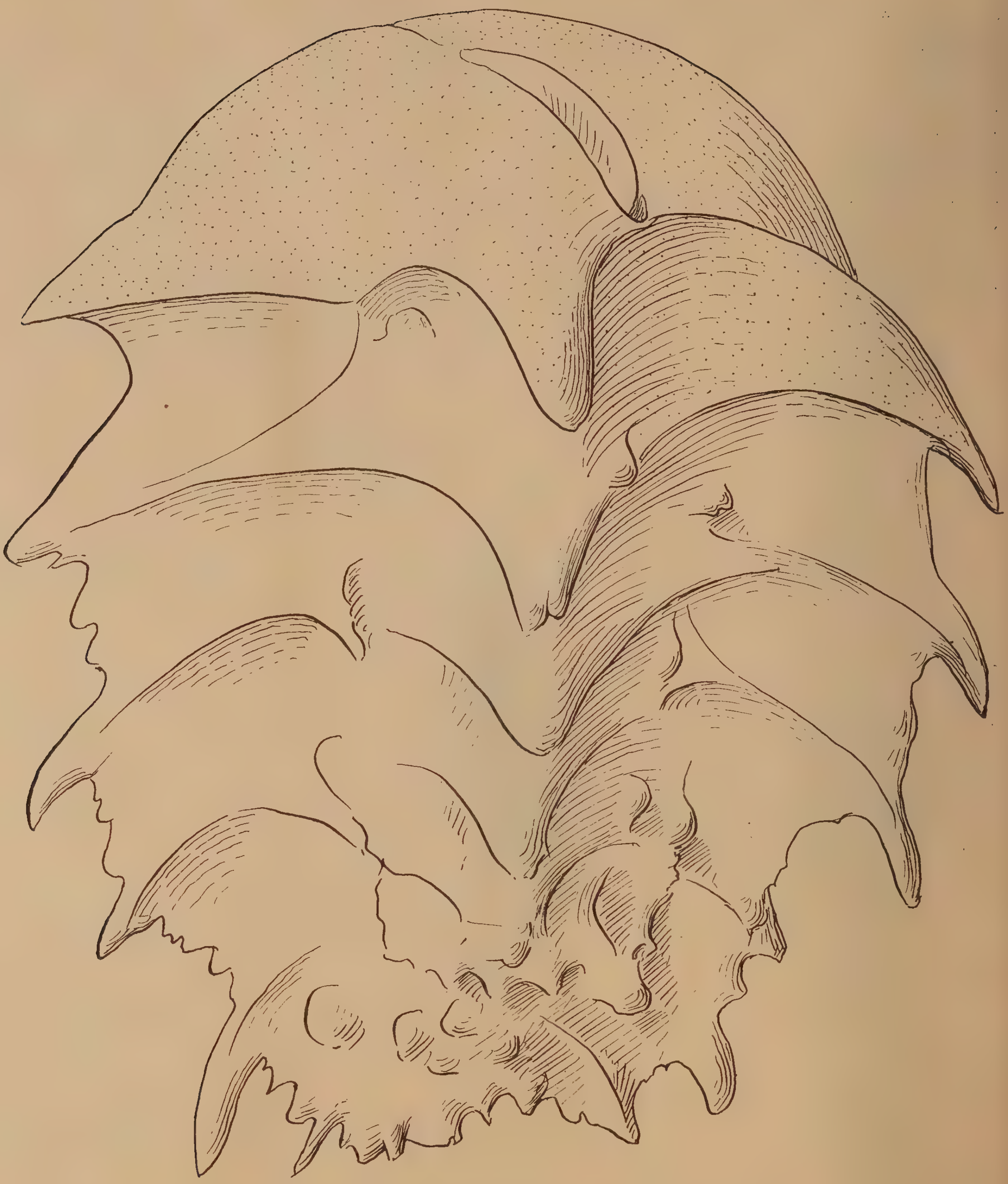


Fig. 188. *Ehrenbergina pacifica.* Large megalospheric specimen, ventral side. × 480.

loculus, as is a rule in most Foraminifera. In a small specimen with very large proloculus it was found, that the proloculus was followed only by biserial chambers, the triserial set thus being

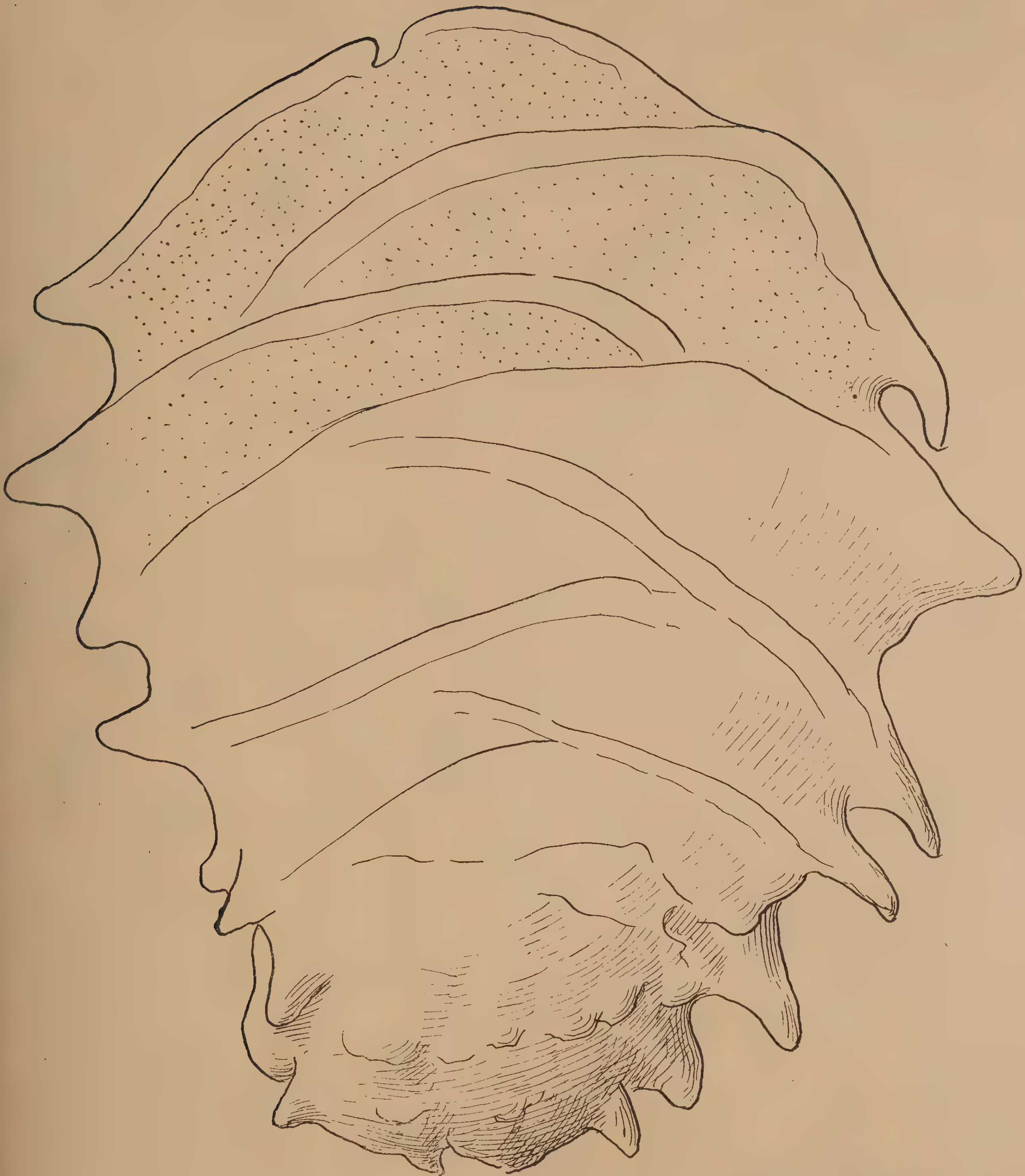


Fig. 189. *Ehrenbergina pacifica.* Large megalospheric specimen, dorsal side. × 480.

repressed. Two very large specimens, with a length of 0,43 and 0,8 mm, showed to be microspheric. They were built up by a series of five sets of coiled chambers, following a proloculus with diameter of 8 μ. Then five sets of straight pairs of chambers were added. The specimens were very coarsely spinous, in this way pointing to the typical characteristics of *E. hystrix*.

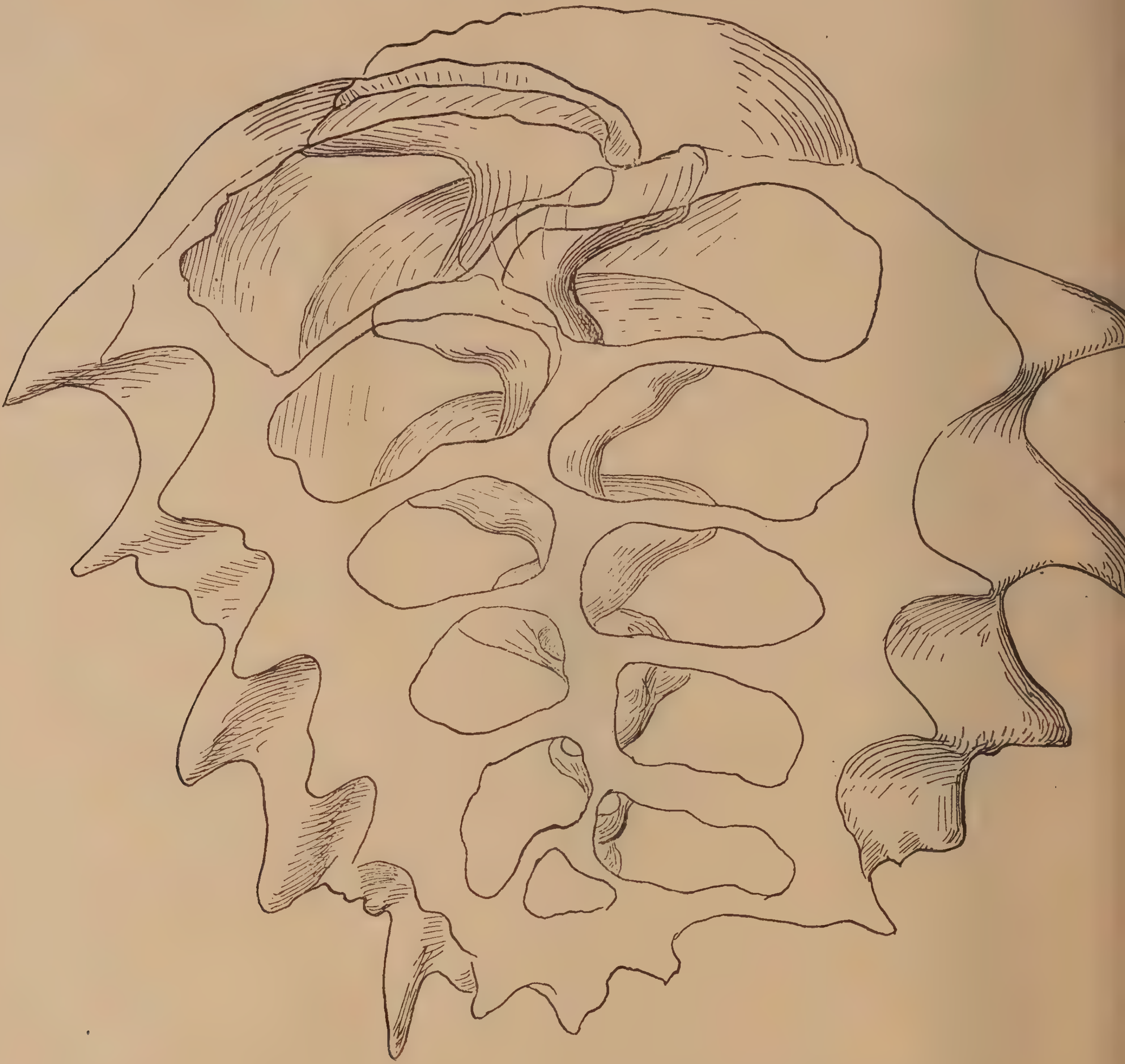


Fig. 190. *Ehrenbergina pacifica*. Large megalospheric specimen, section tangential to axis, showing toothplates. × 480.

The species was moreover found in

St. 49ª, 8° 23′ S., 119° 4′ E., depth 69 m.
St. 280, 8° 17′ S., 127° 30′ E., depth 1224 m.

So all specimens were found in the eastern part of the region, in depth ranging from 69-1224 m.

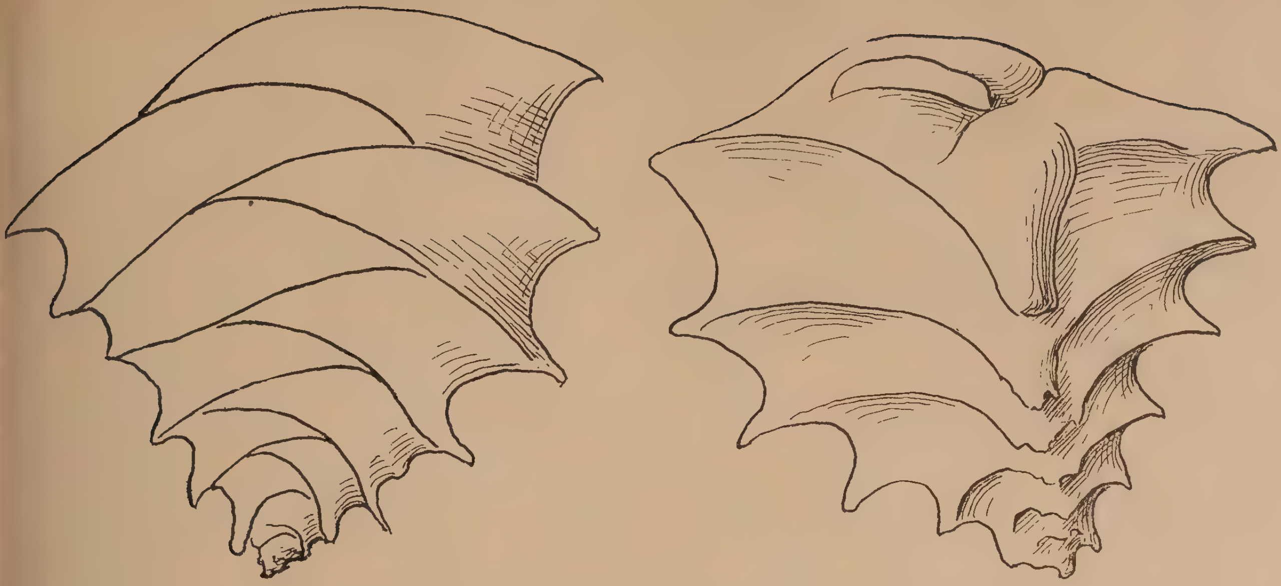


Fig. 191. *Ehrenbergina pacifica.* Microspheric specimen, × 100, ventral and dorsal view.

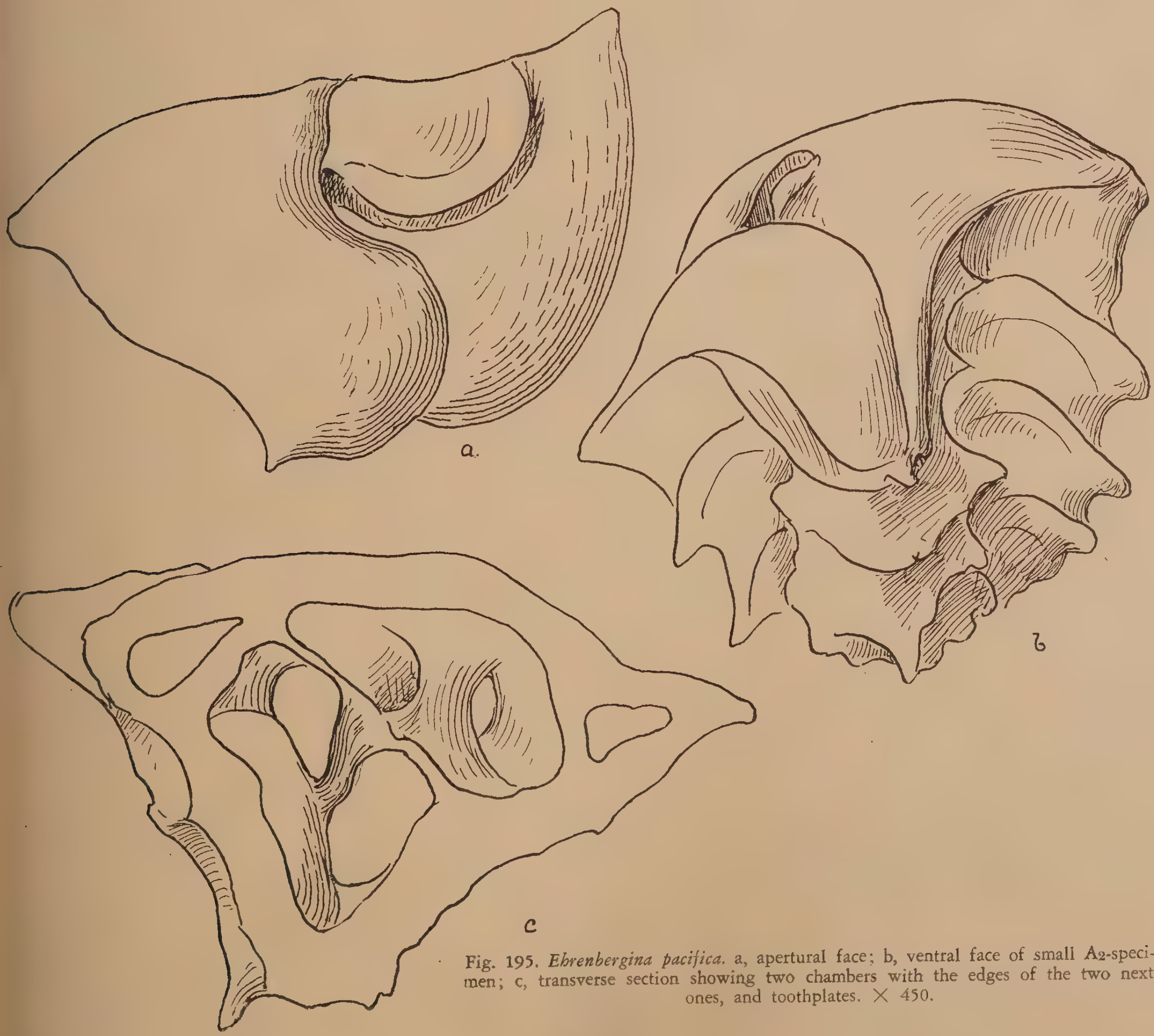


Fig. 195. *Ehrenbergina pacifica.* a, apertural face; b, ventral face of small A_2-specimen; c, transverse section showing two chambers with the edges of the two next ones, and toothplates. × 450.

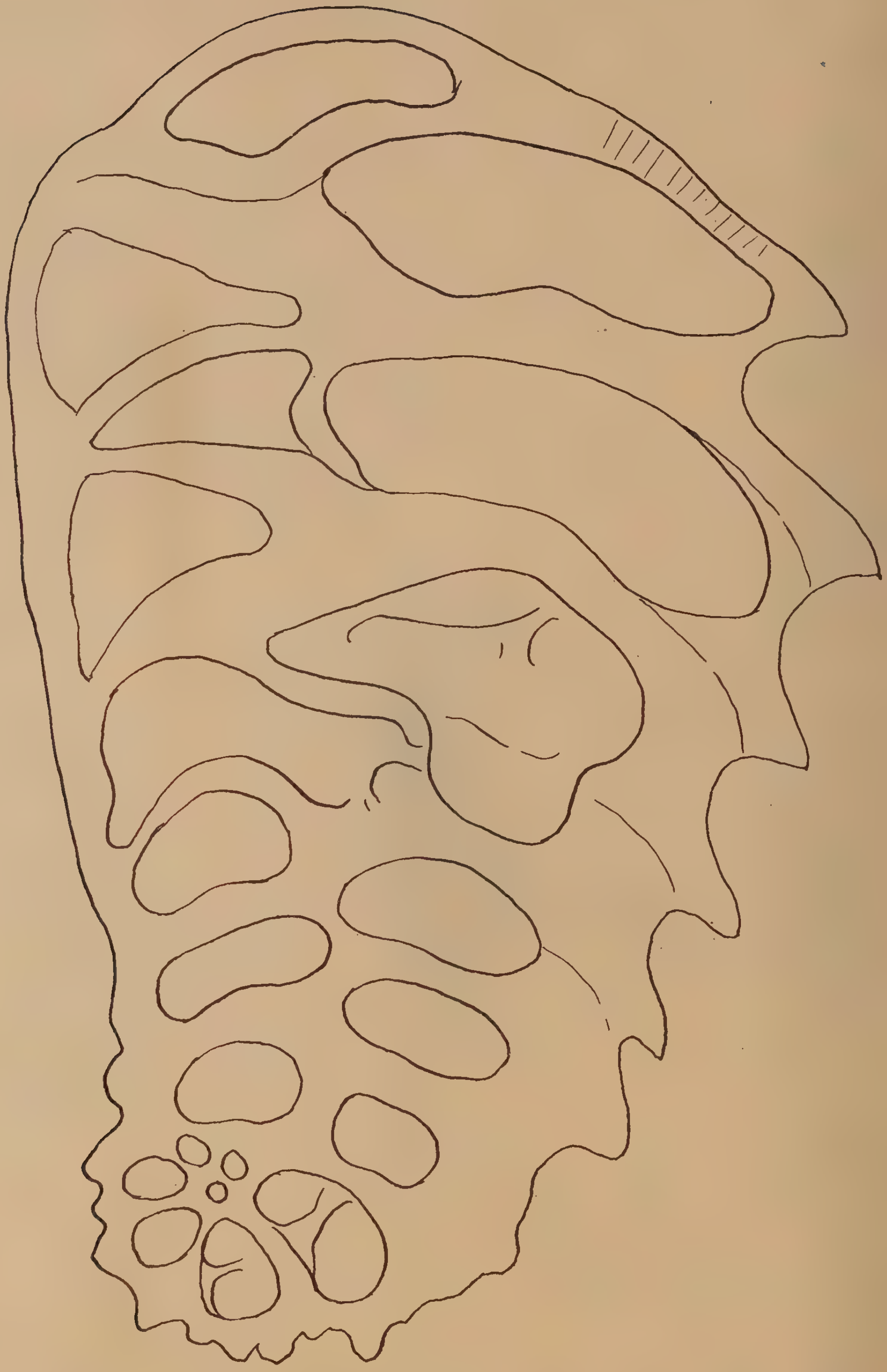


Fig. 192. *Ehrenbergina pacifica.* Longitudinal section, showing initial coil of microspheric specimen. × 480.

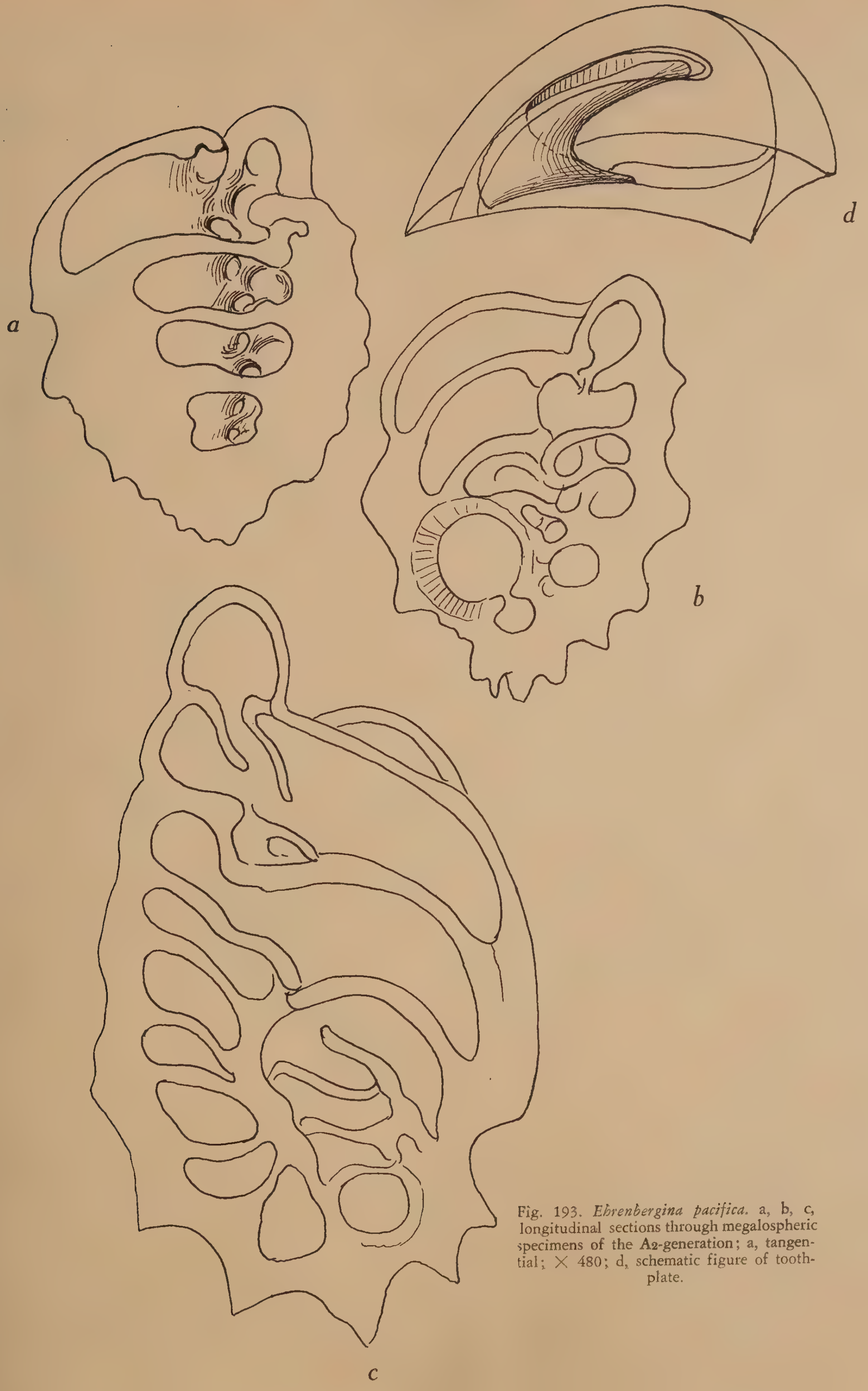


Fig. 193. *Ehrenbergina pacifica.* a, b, c, longitudinal sections through megalospheric specimens of the A_2-generation; a, tangential; × 480; d, schematic figure of toothplate.

The species has been called formerly *E. serrata;* Cushman gave it a new name, *E. pacifica* (U.S. Nat. Mus., Proc., 1927, Vol. 70, No. 2665, p. 5, pl. 2, fig. 2).

This study shows without any doubt, that *Ehrenbergina* is nothing else but a true *Cassidella,* most of the species with spines, some, however, even without them, as is the case in *E. pupa* (d'Orbigny). d'Orbigny himself regarded this species as a real *Cassidulina.*

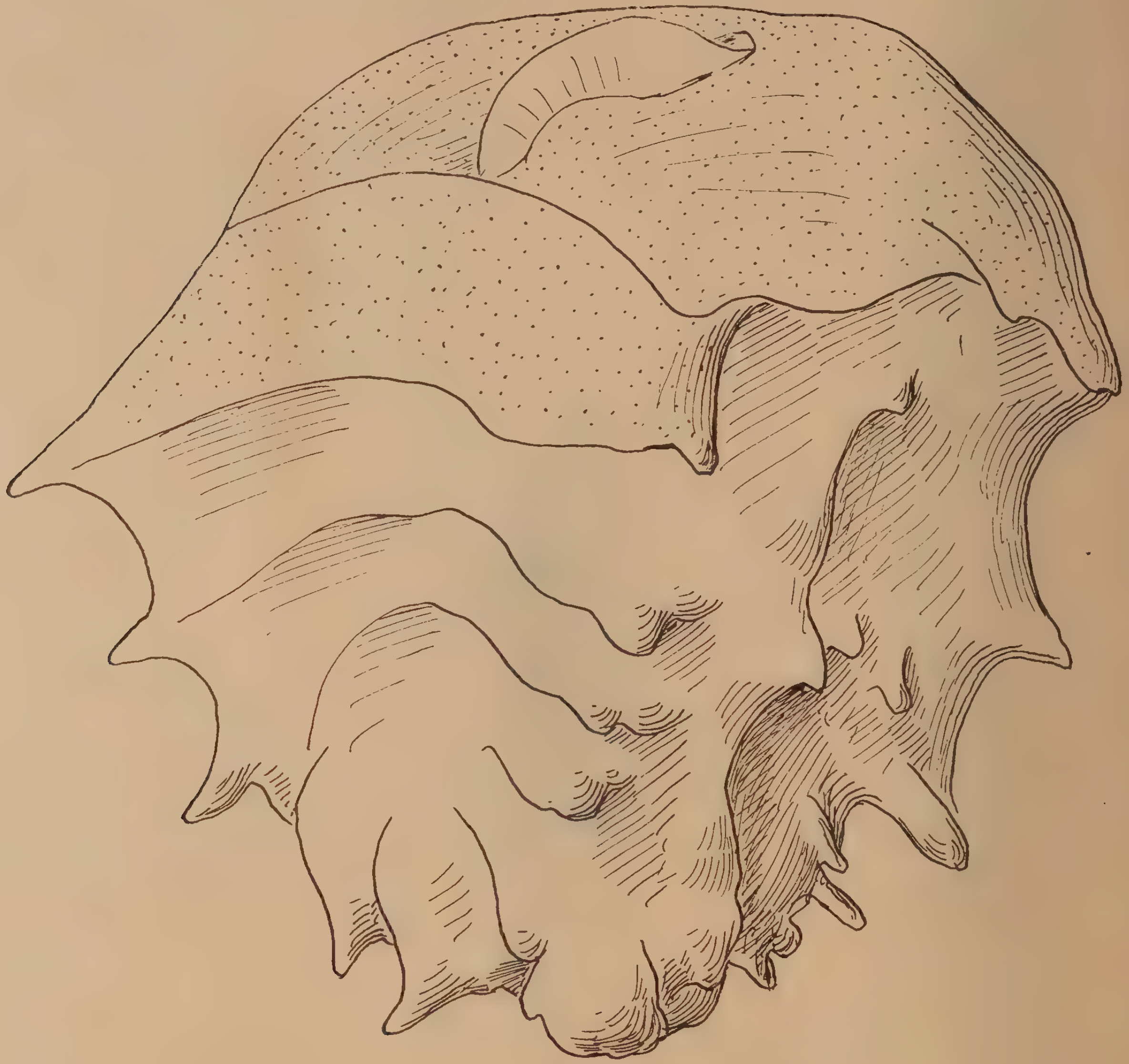


Fig. 194. *Ehrenbergina pacifica.* Large A2-specimen, ventral side. × 480.

All specimens studied from the neighbourhood of Flores showed no trace of the radiating lines, mentioned by Cushman and others in *Ehrenbergina hystrix.* Here we have dealt with a different species, *E. pacifica* Cushman. But, as the difference with real *E. hystrix* is but trivial, this species may be nothing but a geographic variety.

1943 G. Colom published a paper on new species of Foraminifera of Mallorca (Publ. Bol. Real Soc. Espanola de Hist. Nat., Vol. 41, 1943), in which he described the species *Cassidulina crispula,* which differs in only somewhat weaker spines from the *Ehrenbergina hystrix* of Flores.

He says, that the species belongs to those forms, which are known as *E. pupa* d'Orb., but he names it with *Cassidulina* for its structure. This is an indication moreover for the fact, that this *Ehrenbergina* is nothing else but *Cassidulina,* and so, as a missing link may be found in this *C. crispula,* the genus *Ehrenbergina* is very closely allied to *Cassidulina* and *Cassidulinoides.*

Genus **Cassidulina** d'Orbigny

This genus shows the coiling which has begun in *Ehrenbergina,* much more developed. As in *Ehrenbergina* the largest breadth of the chambers is found in a direction parallel to the axis of coiling, those species which have this largest breadth in the same direction may be regarded as the more primitive species, such as *Cassidulina subglobosa.* An other difference between *Ehrenbergina* and *Cassidulina* lies in the situation of the aperture. In real *Ehrenbergina* the aperture is obliquely situated in such a high grade, that it runs parallel to the upper margin of the chamber, whereas in real *Cassidulina* it is situated quite close to the ventral suture of the chamber. This difference is of some importance, as some older forms, known as *Cass. constellata, arenasensis, crispula* and *havanensis* from the Eocene, in reality are nothing but *Ehrenbergina.* So real *Cassidulina* appears in the Miocene, where it is always a simple form.

Later forms often show the tendency to have the largest breadth of their chambers in the same plane as the coiling of the test, and then they become lens-shaped and compressed, often showing a carina also.

These species seem to be the highest forms of the genus. In these forms the alternation of the chambers lead to a peculiarity, in respect to the margin of the shell, which is also found in other species with globular shells, but which in these forms does not become so apparent. In those compressed forms however the chambers show a very short portion at one of the sides of the margin and a much broader part at the other. When seen from aside, the test thus shows a very small chamber-part and a large one alternating, running up to the centre of the test. In one case, the Oligocene form which I found in a drilling-sample, kindly given to me by the Geological Survey of the Netherlands, and which species I identified with *Cassidulina tortuosa* Cushman, the chambers become narrow toward the central part and are somewhat curved, thus forming quite the same ornamentation of the walls, as is found in *Amphistegina.* The aperture which always is directed with its upper part towards the larger chamber part, in this species as in others, alternates its direction in each successive chamber.

Cassidulina subglobosa Brady
(Figs. 196-199)

The species occurred in most of the gatherings in the Mentawei-basin, south of Sumatra, in depths ranging from 222 up to 928 fathoms, and was common at St. 1° 51′ S., 99° 36′ E., 683 fathoms, 2° 17′ S., 99° 56′ E., 613 fathoms, and 2° 58′ S., 99° 47′ E., 928 fathoms, with a bottom-temperature of 3°,8 C. It occurred too in single specimens at

St. 226, 5° 26′ S., 127° 36′ E., depth 1595 m, and
St. 266, 5° 56′ S., 132° 47′ E., depth 595 m.

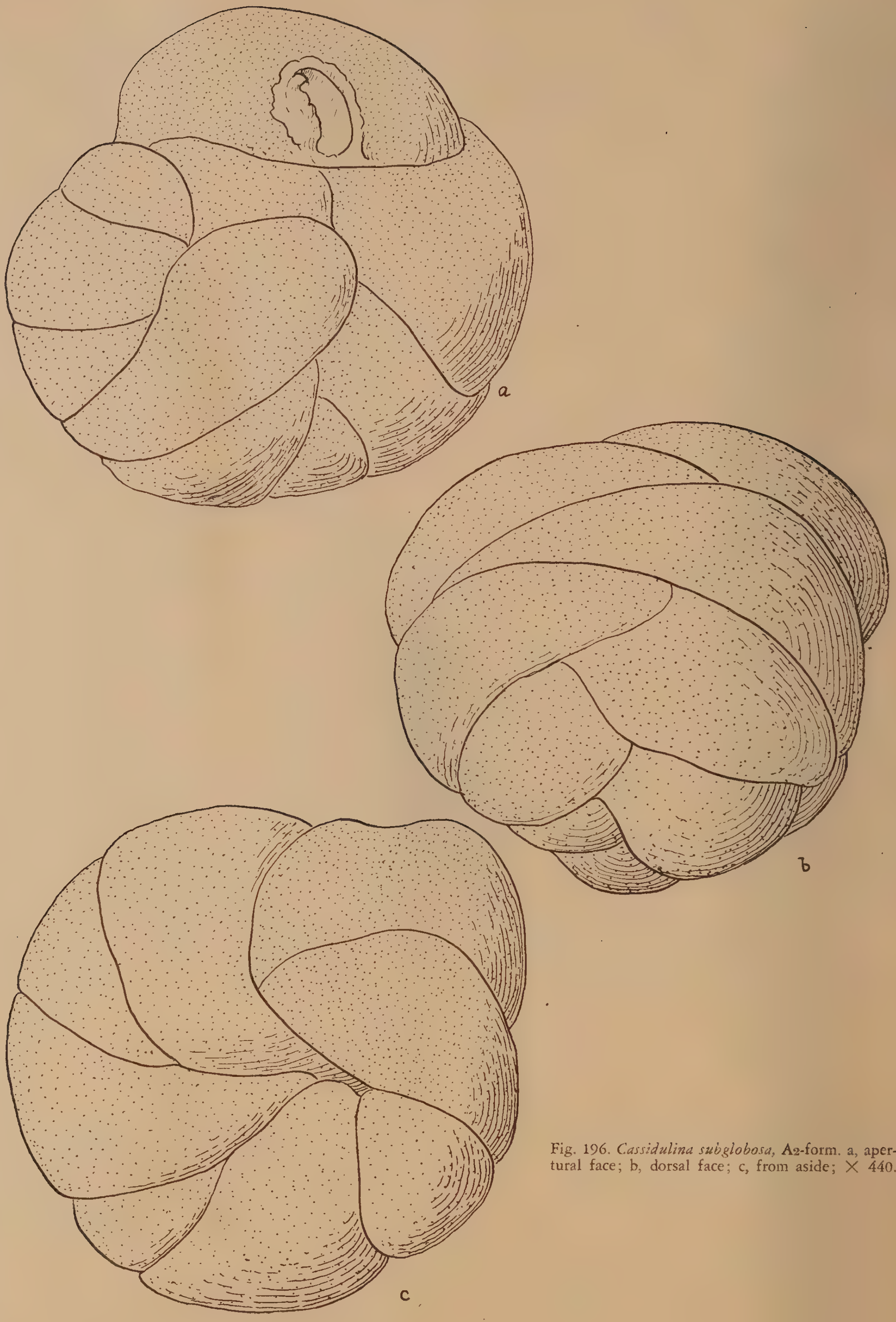


Fig. 196. *Cassidulina subglobosa,* A_2-form. a, apertural face; b, dorsal face; c, from aside; × 440.

In the gatherings in or about the Savu-Sea, near Flores, it lacked totally. The species was found in three different generations.

B-generation. Test subglobular, chambers distinctly alternating, last chamber with truncate apertural face, in which the obliquely situated aperture is situated in the middle, with its top toward the overlapping part of the chamber, as in all *Cassidulinae.* Toothplate reduced, the attached part always at the lower border of the oblique aperture, sometimes irregularly sawed, most smooth. Walls relatively thick, with distinct pores, opaque. Diameter of test about 0,58 mm. The difference in shape with the two other generations lies mainly in the largeness of the test, together with the fact, that the last-formed chambers have the tendency to uncoil, so that the test becomes slightly egg-shaped.

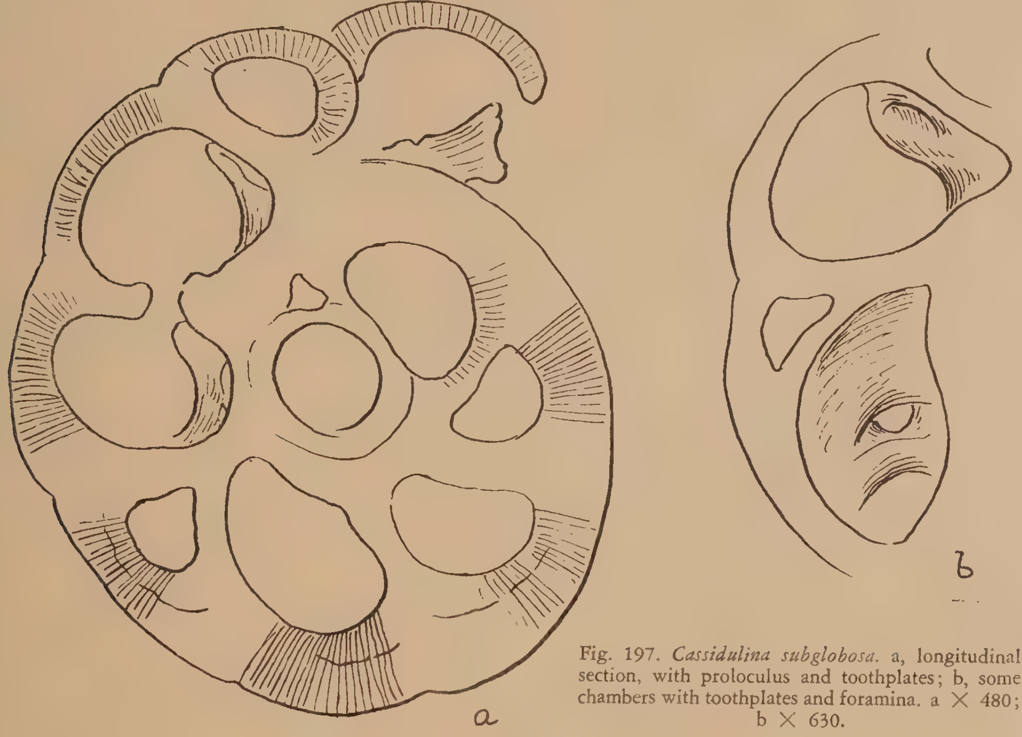


Fig. 197. *Cassidulina subglobosa.* a, longitudinal section, with proloculus and toothplates; b, some chambers with toothplates and foramina. a × 480; b × 630.

It has been figured by Rhumbler, Plankton Expedition, pt. I, Taf. 18, fig. 6.

A_1-generation. Always very small, diameter up to 0,18 mm, nearly globular, with alternating chambers which end rounded at the centre, without real central knob. Last chamber very broad, extending over the whole breadth of the test. Chamberwalls very thick, opaque, pores somewhat larger than in the B-form, and set somewhat more apart. Aperture not so long and oblique as in the B-form, with the same short toothplate which shows a smooth border, somewhat protruding from the aperture. Proloculus about 15 μ diameter, 8 chambers in the last whorl, nearly 2 whorls in total, whereas the microspheric form shows 2½ whorls with 10 chambers in the last whorl.

A_2-generation. Larger than in the A_1, with diameter of shell about 0,22-0,30 mm. Chambers somewhat more pointed toward the middle of the test, 8-9 chambers in the last whorl. Walls thick and opaque, with fine pores. Aperture somewhat oval in shape, oblique, with its upper part directed toward the overlapping part of the chamber, with reduced toothplate which is attached to the lower

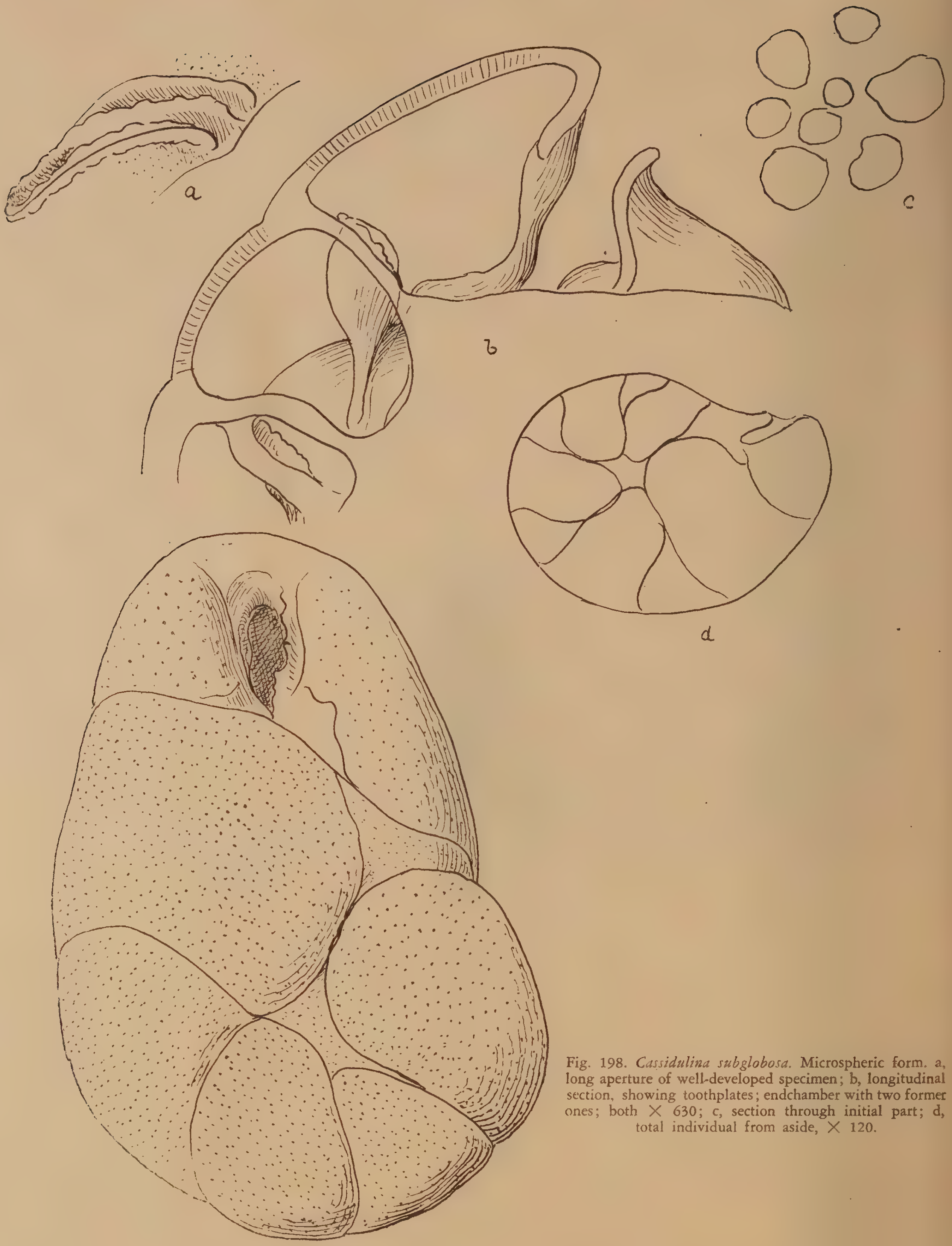


Fig. 198. *Cassidulina subglobosa.* Microspheric form. a, long aperture of well-developed specimen; b, longitudinal section, showing toothplates; endchamber with two former ones; both × 630; c, section through initial part; d, total individual from aside, × 120.

border of the mouth, and often shows very irregular sawing, always with rounded teeth. Proloculus with diameter of about 30 μ, total number of chambers about 11.

This species occurs also in the Caribbean Sea and here too both A-forms can be found together. They show the peculiarity, as in all *Cassidulinidae,* that the form with the smaller proloculus is the smaller form. Cushman mentions the small A_1-specimens from this locality (Nat. Mus., Bull. 104, pt. 3, p. 128), but suggests it to be a variety.

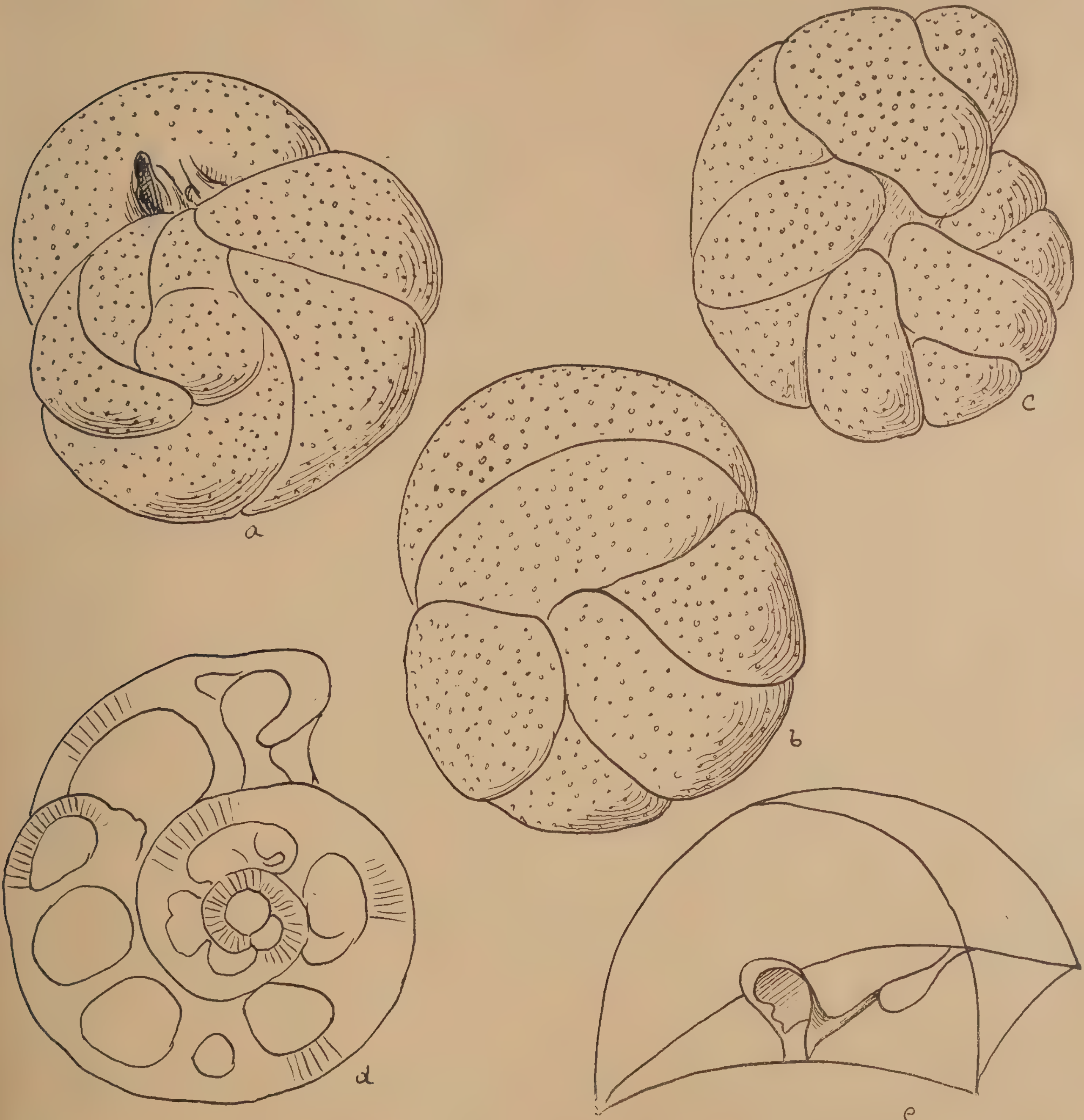


Fig. 199. *Cassidulina subglobosa.* A_1-generation. a, b, c, three views of an individual; d, longitudinal section; e, schematic figure of toothplate. All but e × 480.

The pores are more or less distinct and the distance between is about 6 μ.

Cassidulina laevigata d'Orbigny
(Figs. 200-203)

The species occurred at St. 8° 11′ S., 117° 01′ E., 620 fathoms, at 8° 15′ S., 118° 56′ E., depth 340 fathoms and at 1° 51′ S., 99° 36′ E., depth 683 fathoms; it was abundant at 2° 26′ S., 99° 35′ E., depth 582 fathoms, bottom temperature 6,6° C. The species is of a very wide spread distribution; I stated it in a gathering at Dog's Bay, Connewara, West Ireland, in several localities south of Iceland, in the Bay of Naples (Faraglioni, depth about 400 m). The three generations could be traced easily. They were:

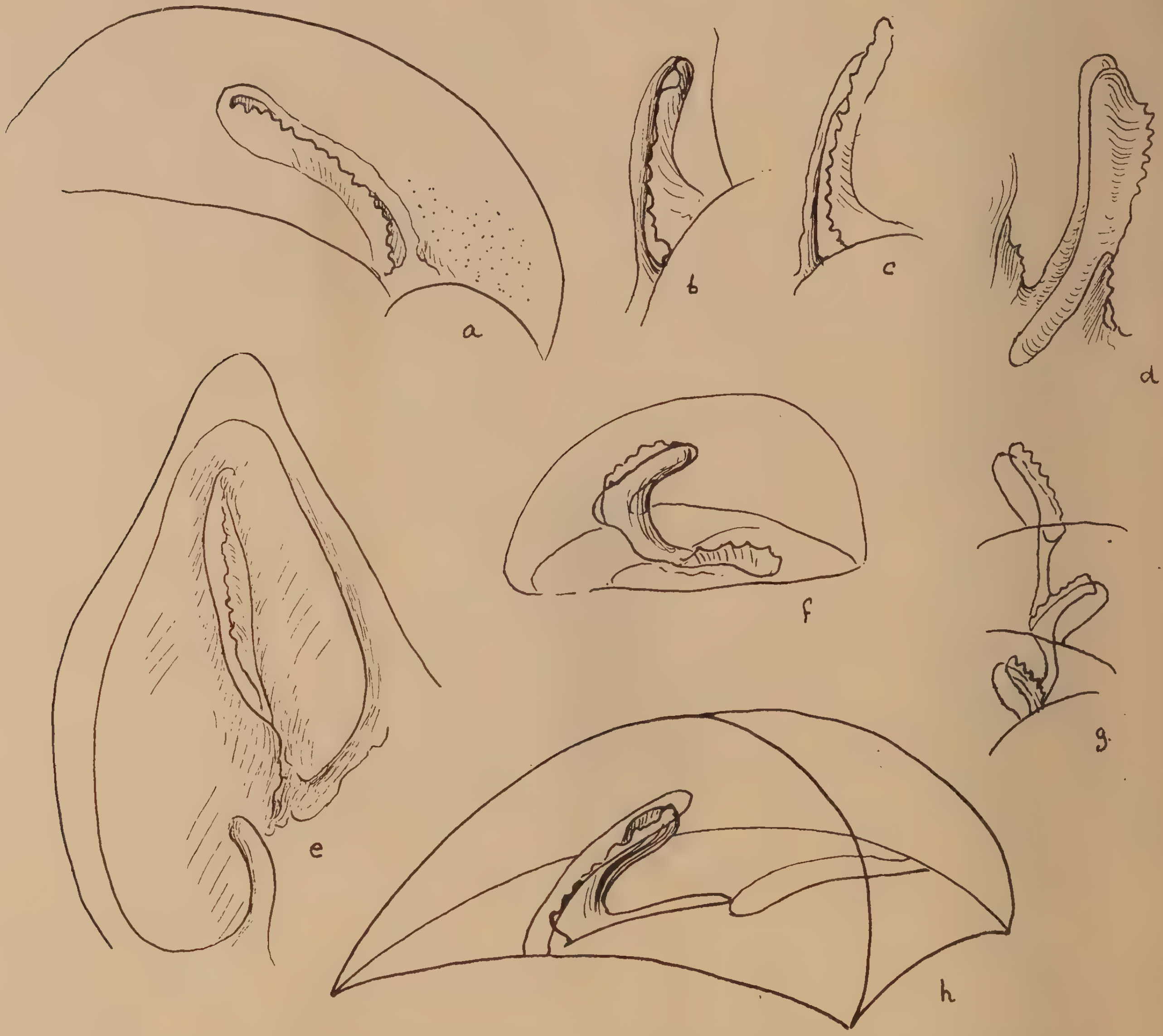


Fig. 201. *Cassidulina laevigata.* a, apertural face, showing pores; b, c, toothplates, seen from aside; d, toothplate seen from behind, with its attachment to former plate; e, apertural face of one of the chambers; f, toothplate in opened chamber; g, toothplates in successive chambers; all figures × 460; h, schematic drawing of toothplate.

B-generation. Large specimens, with a diameter of about 0,62 mm, and 11-12 chambers in

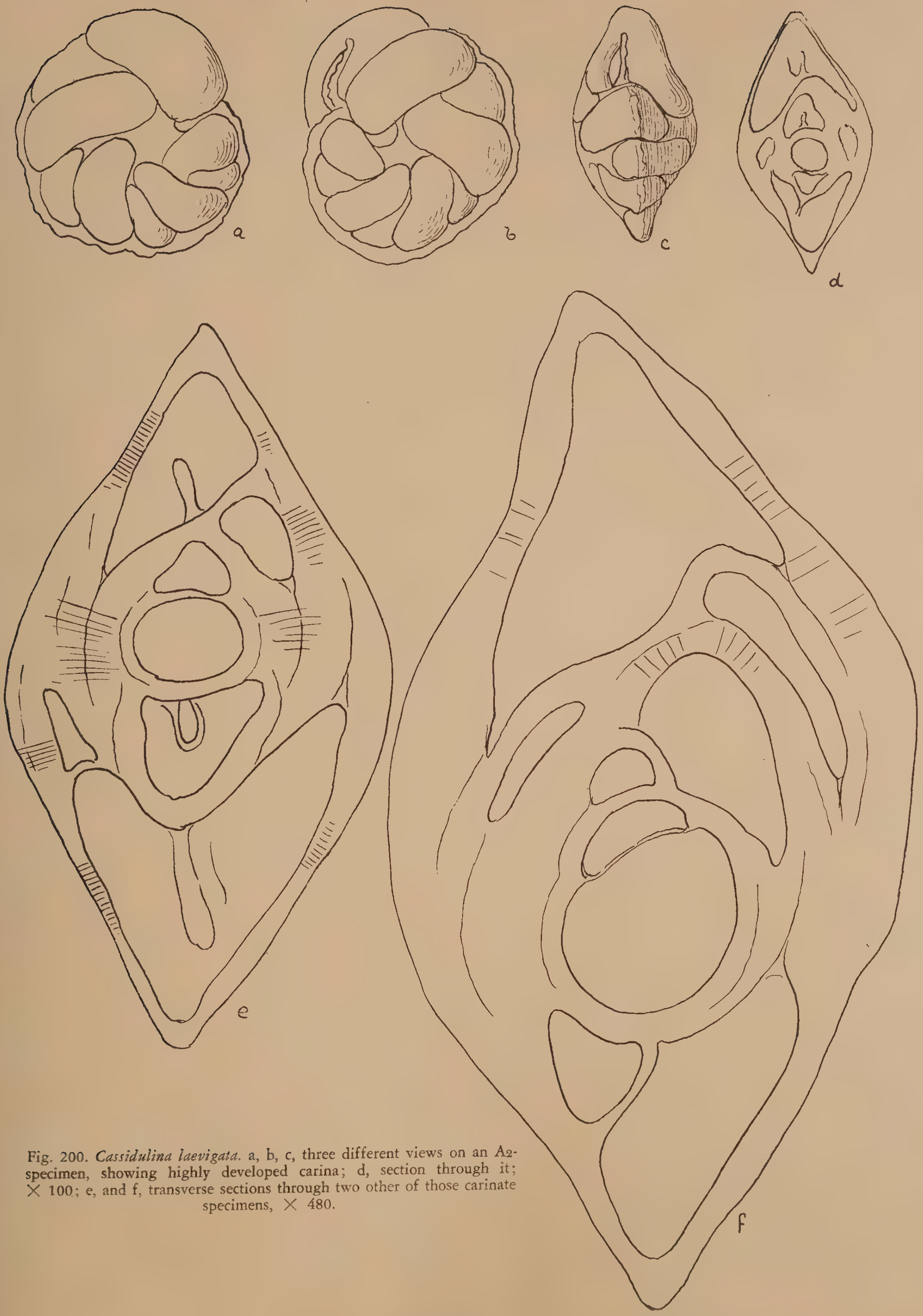


Fig. 200. *Cassidulina laevigata.* a, b, c, three different views on an A2-specimen, showing highly developed carina; d, section through it; × 100; e, and f, transverse sections through two other of those carinate specimens, × 480.

the last whorl. The centre of the test shows a large central knob, with fine tubercles. The chambers end toward the knob very abruptly. The carina is relatively broad. The proloculus measures only 6 μ, and is followed by 3½ whorls; spiral walls between the whorls very thick.

A_1-generation. Individuals small, diameter about 0,23 mm, proloculus 20 μ. 10 chambers in the last whorl. The carina is scarcely visible, the central knob very small, the walls of the chambers, and the spiral sutures between the whorls are thin. The proloculus is followed by only 2 whorls.

A_2-generation. Larger individuals, diameter from 0,31-0,44 mm, proloculus 41-68 μ. 9-10 chambers in the last whorl. Central knob larger than in A_1, but smaller than in B. Chambers bluntly ending toward the knob. Carina well-developed. Spiral sutures between whorls relatively thick. 2 whorls of chambers.

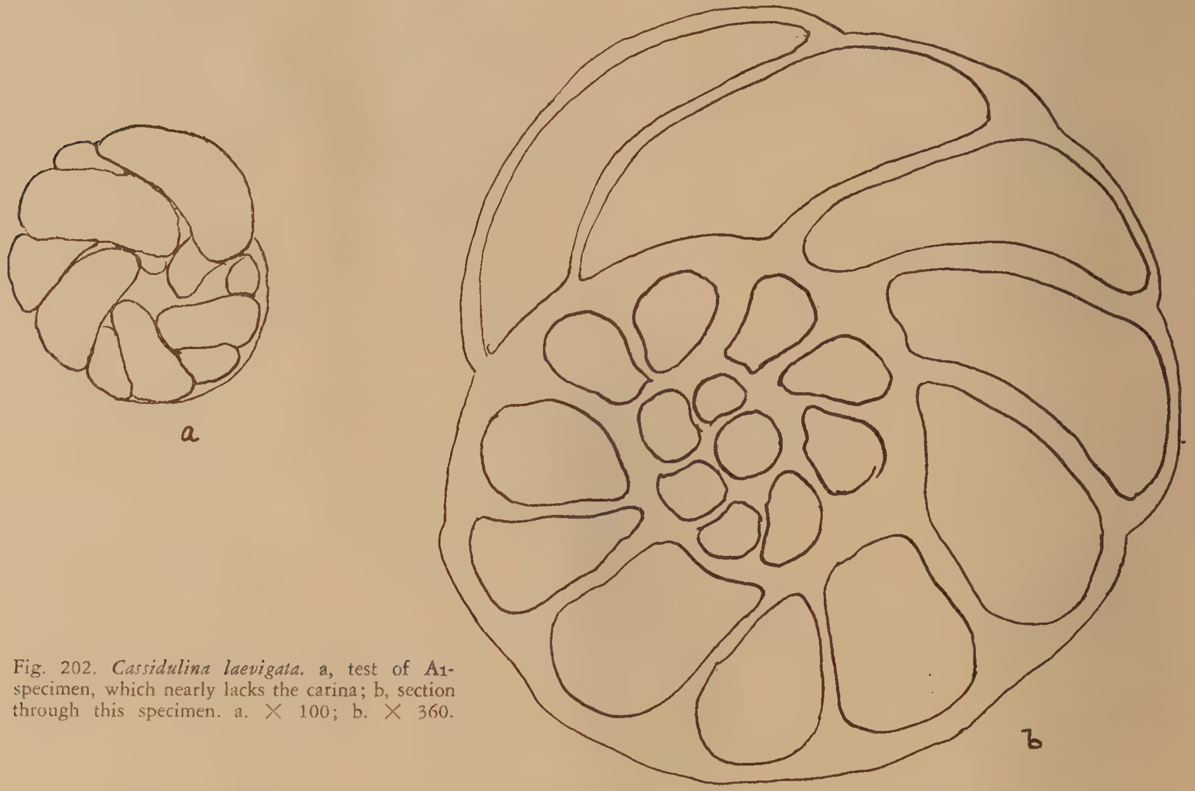


Fig. 202. *Cassidulina laevigata.* a, test of A_1-specimen, which nearly lacks the carina; b, section through this specimen. a. × 100; b. × 360.

The main characteristics are unvariable in all localities over the world: the compressed test, the more or less carinate periphery, the elongate, slightly curved aperture, and the sawed, slightly protruding toothplate. There is only a slight difference in the species from the Pacific, in which the length of the aperture is shorter than in mediterranean and Atlantic specimens.

General characteristics: Pores in the wall relatively scarce and separate from each other, not so fine as in many other species, but much finer than in "*Cassidulina*" *islandica* Nørvang. Chambers alternating. Aperture obliquely placed, with its higher end always directed toward the overlapping chamber part. Thus the aperture alternates its position too. Aperture loop-shaped with a protruding and a sunken border. At the protruding border the toothplate is fastened, with a typically sawed ridge, but nothing of a free folded part. It originates from the lower part of the former toothplate, runs nearly invisibly along the basal wall of the chamber toward the next aperture, where it forms the fastened toothplate at the opposite border of the aperture. So it belongs to the reduced toothplates, typical for all species of *Cassidulina* and its allies. The sawed upper border with its sharp small points is very characteristic, since it occurs in no other *Cassidulina* in this shape. In many cases the upper part of the plate is not sawed and ends with a rounded angle.

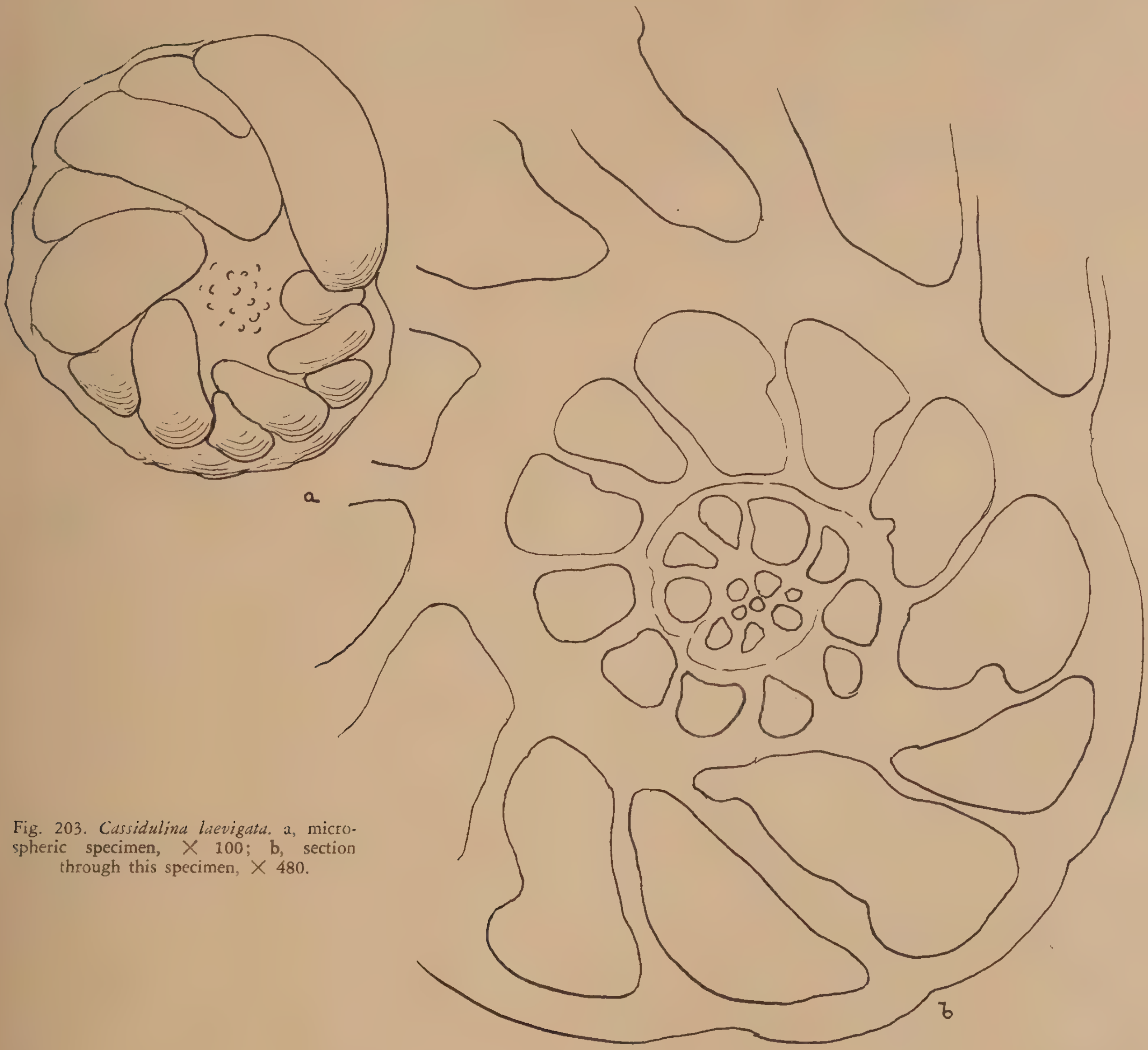


Fig. 203. *Cassidulina laevigata.* a, microspheric specimen, × 100; b, section through this specimen, × 480.

The central knob consists of relatively clear substance, formed by the thickened sidewalls of the chambers. The margin is formed by the chamberwall itself, without apart thickening, and thus the chambers show a pointed angle at the margin in transverse section. In transverse section the shell is nearly rhomboid, width about ½ the diameter.

Cassidulina tortuosa Cushman

(Figs. 204-206)

In an Oligocene sample set to my disposal by the Dutch Geological Survey many specimens occurred which at first sight resembled some simple *Amphistegina.* The shells show a smooth and shining surface, somewhat lobulated margin which shows a sharp edge, with hyaline rounded carina. The walls are very finely perforated. Both sides are equal, but the chambers are very typically arranged. Alternating a chamber reaches towards the centre of one side, and overlaps the margin only halfways at the other. Since each chamber is somewhat curved when it reaches the centre of one side, a very typical ornamentation is formed, very much alike the structure of the chambers in young *Amphistegina radiata.*

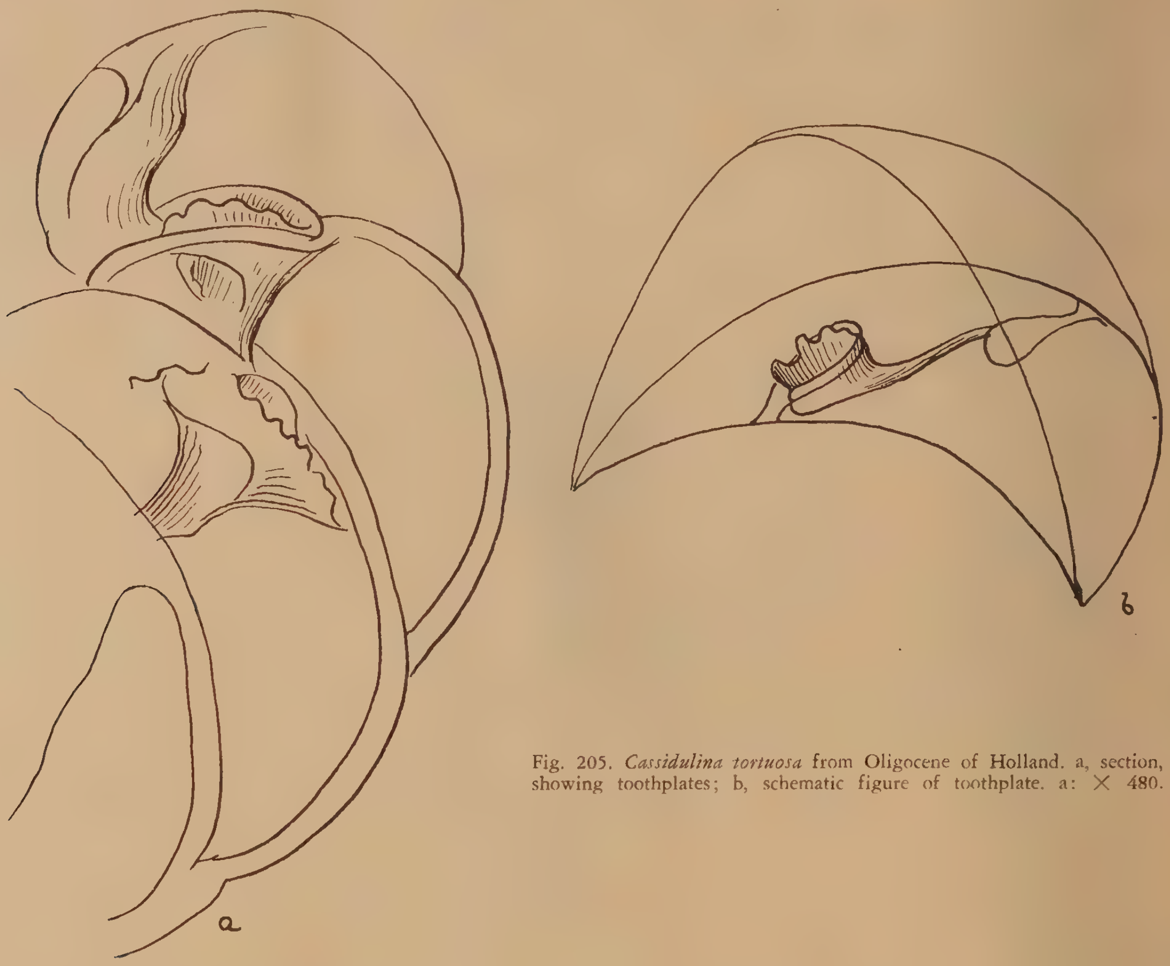


Fig. 205. *Cassidulina tortuosa* from Oligocene of Holland. a, section, showing toothplates; b, schematic figure of toothplate. a: × 480.

The aperture is a long, narrow slit, obliquely standing at the margin, with its top directed towards the long side of each chamber. As this long side alternates in respect to the margin, each next chamber shows its aperture directed to the opposite side. At one side of the aperture, the side which is opposite to the longer part of the chamber, a dentated tooth is visible, which tooth forms the

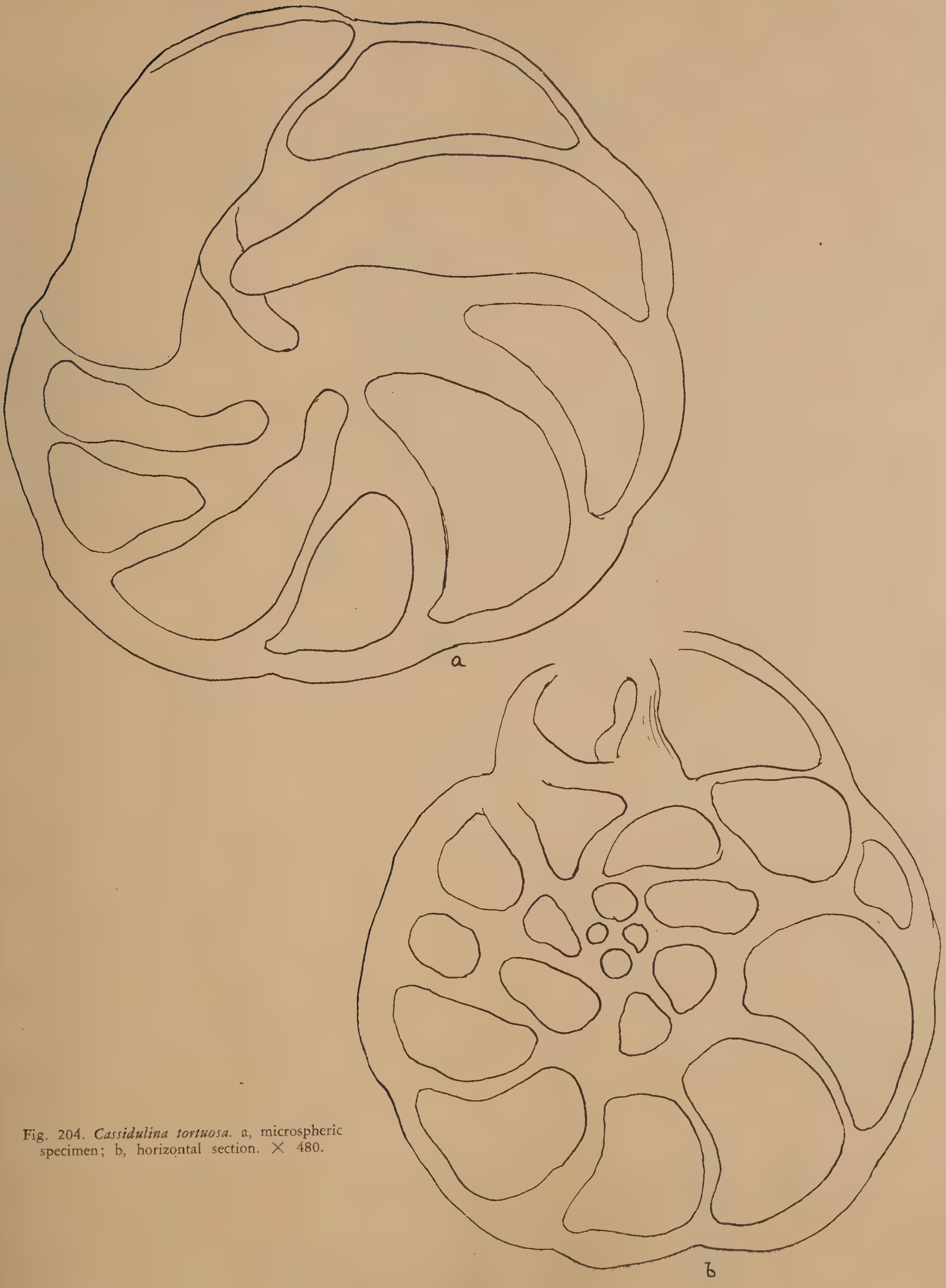


Fig. 204. *Cassidulina tortuosa.* a, microspheric specimen; b, horizontal section. × 480.

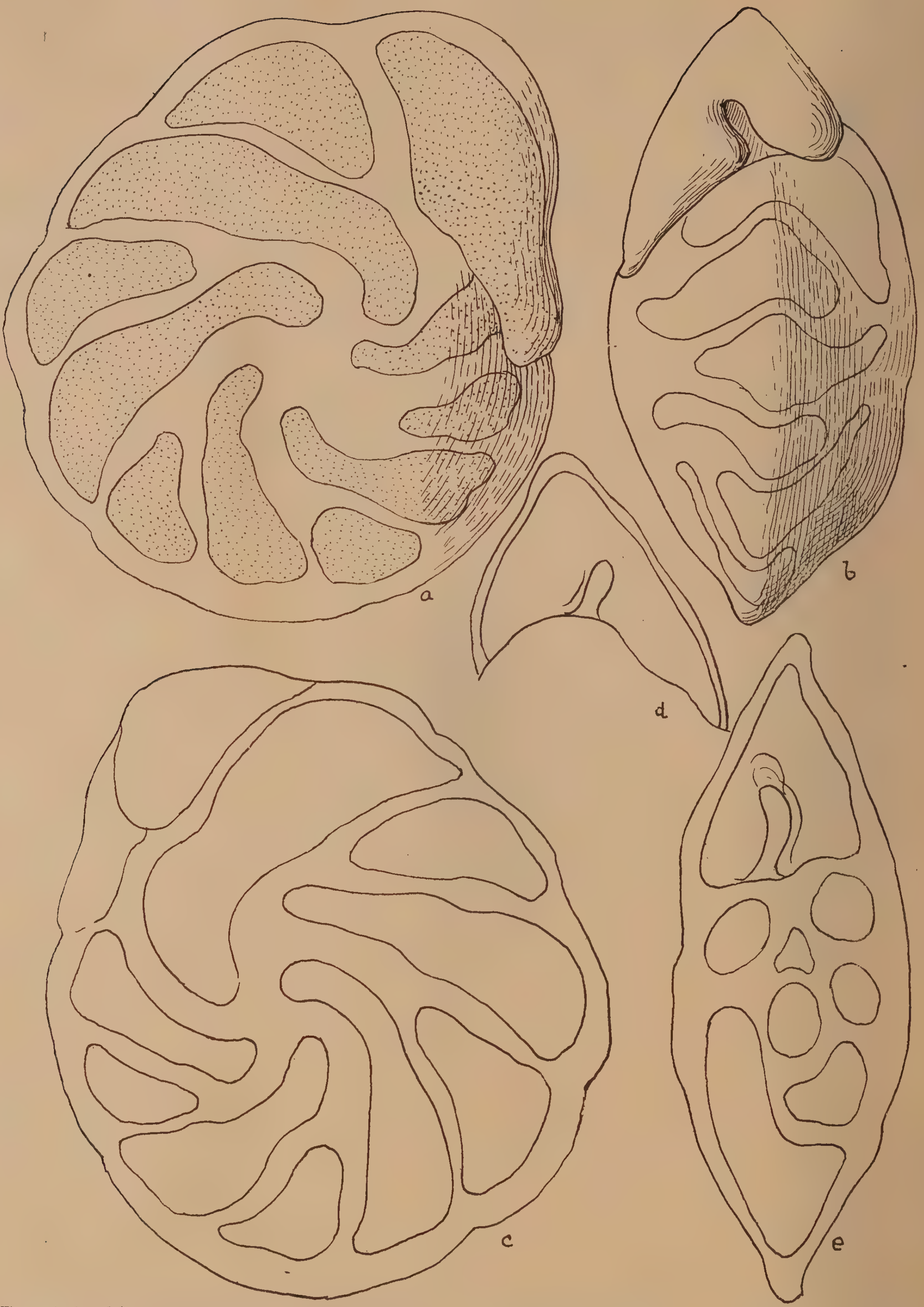


Fig. 206. *Cassidulina tortuosa,* from the Oligocene of Holland. a, b and c, views on megalospheric test; d, apertural face of chamber, preceding the last-formed one, showing that direction of aperture always is connected with direction of chamber; e, transverse section. × 420.

end of a typical toothplate which is very simple, folded, and typically cassiduline. Thus the species is a real *Cassidulina,* and resembles very much *C. tortuosa.* A specimen with diameter of shell of 0,30 mm, had a proloculus with diameter of 10 μ, may be microspheric. An individual of diameter of 0,27 mm showed to be megalospheric with proloculus-diameter of 30 μ.

The alternation of the situation of the aperture, together with the peculiar shape of the alar prolongations of the chambers and the fine pores, while the test is planospirally coiled, shows a very striking set of characteristics, found also in all *Cassidulinae.*

The species has been found by Cushman in the Pliocene of America.

Genus **Cassidulinoides**

In the year 1927 Cushman erected a new genus, *Cassidulinoides,* with the genotype *Cassidulina parkeriana* Brady. Cushman's description runs as follows:

"Test in the early stages like *Cassidulina,* but in the adult becoming uncoiled in a series of alternating chambers; aperture in the young like *Cassidulina,* later becoming terminal."

This description is only applicable to the microspheric forms of several species, while the megalospheric forms of these species do not possess the coiled part or show nearly uncoiled chambers.

Test in the early stages of the microspheric form coiled as in *Cassidulina* or *Ehrenbergina,* but in the adult becoming uncoiled in a more or less regular series of alternating chambers (often biserial); aperture in the young a narrow slit on the suture of the chamber, always more or less oblique, in the adult often becoming more or less terminal [1]). Toothplate always reduced, forming a folded narrow plate just under the aperture, and always attached to the lower border of the aperture.

Since especially the microspheric form shows the coiled first part, and as the B-form always shows the most primitive characteristics of the group, it is obvious, that the genus is an offspring of the genus *Cassidulina* itself. Cushman mentions the genus from the Miocene up to Recent. Several species, hitherto known as *Virgulina,* belong to this species while also some *Cassidulina* are nothing but the microspheric form of *Cassidulinoides.*

In the Pacific a species occurs, hitherto known as *Cassidulina pupoides* (d'Orbigny), which belongs to the genus *Cassidulinoides* without any doubt, while in the Caribbean Sea the species *Cassidulina mexicana* Cushman belongs to the genus *Cassidulinoides* too. I shall describe this West-Indian species elsewhere; both species are very closely allied and form together a typical instance of the genus. Often the megalospheric stages are resembling in all ways the new genus *Cassidella,* which genus shows the straight form of megalospheric *Cassidulinoides* also in the microspheric form, thus indicating a very close relation with *Virgulina.*

Species of *Cassidella* are found already in the Upper-Cretaceous and are, on the other hand, the ancestors of *Cassidulina,* as well as of many other groups. It is a peculiar fact that in *Cassidulinoides* a characteristic, shown in an ancient group, once more comes to development, viz. the straight form.

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[1]) This characteristic of a terminal aperture is not very generic, as in several other genera e.g. *Cassidella* some species show this feature likewise. It is here the same question as is found in *Loxostoma* among the *Bolivina*-group. So only the microspheric form remains typical.

Cassidulinoides subsquamosa (Egger)
(Figs. 207-210)

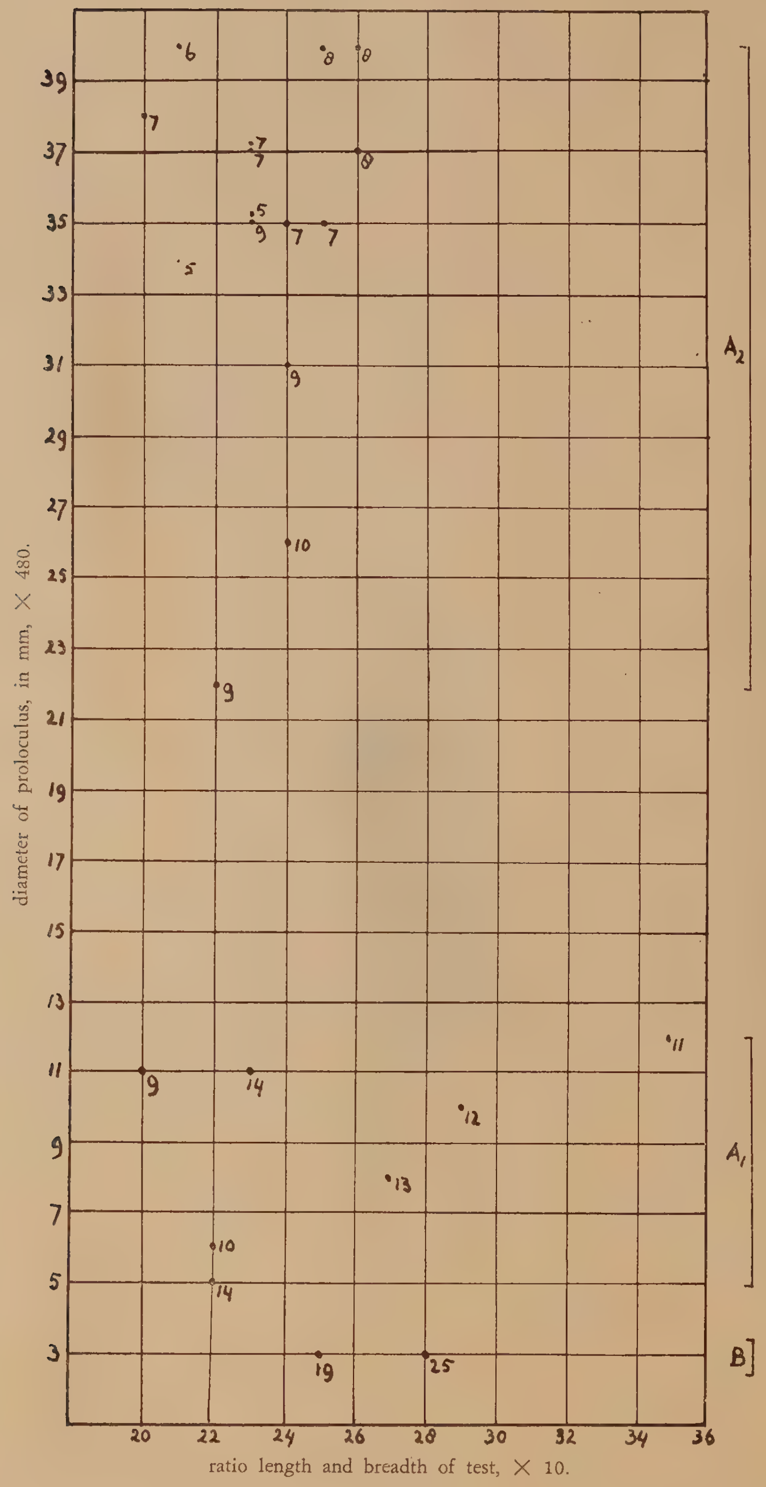


Fig. 207. *Cassidulinoides subsquamosa.* Diagram, showing relation between size of proloculus and ratio between length and breadth of test. The B-individuals with proloculus of about 8 μ diameter show 19 and 25 chambers; those of the A_1-generation have 9-14 chambers, proloculus ranging from 10-25 μ; the A_2-form with proloculus ranging from 45-83 μ, possess 5-10 chambers. The latter group is the stouter one, as the diagram shows.

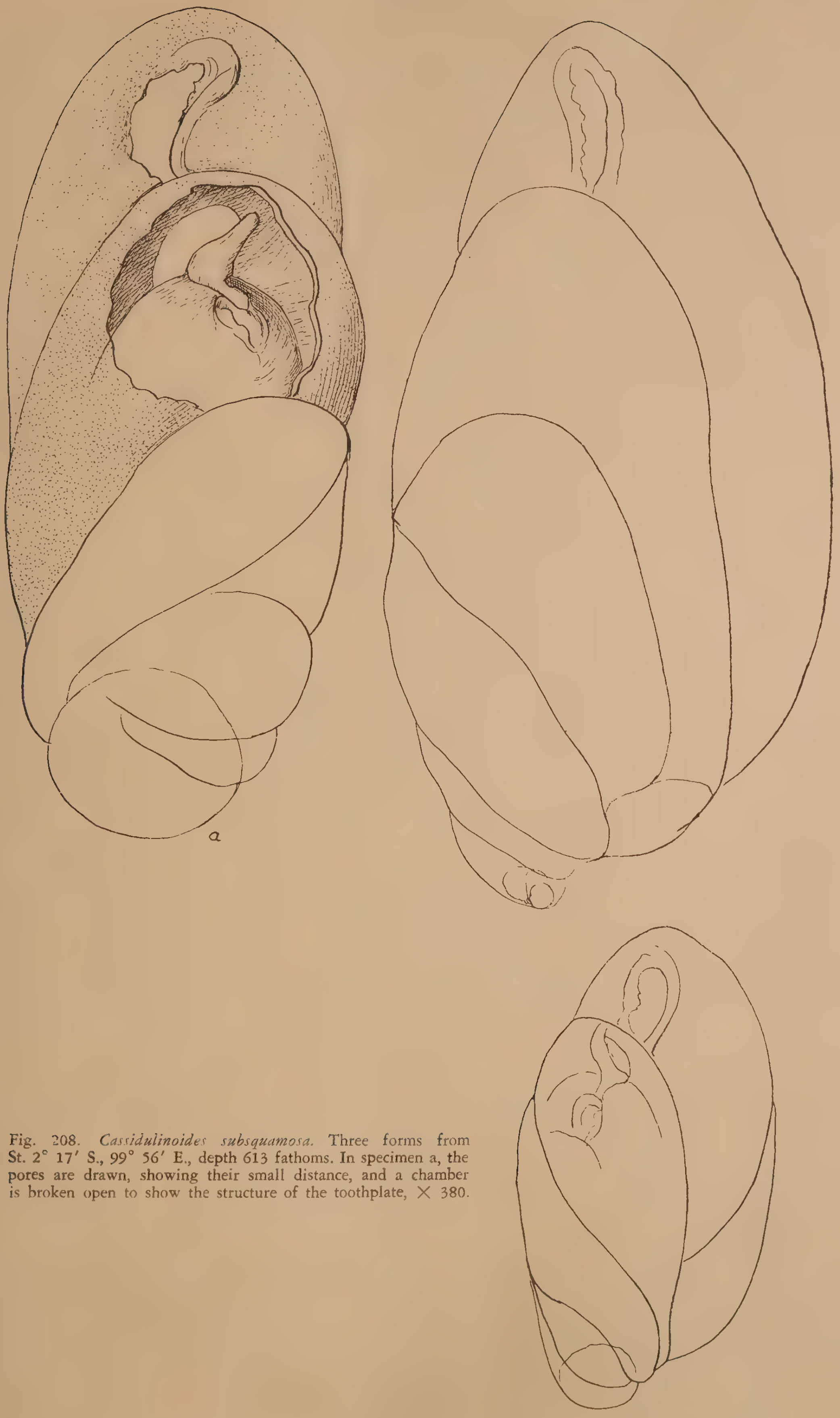


Fig. 208. *Cassidulinoides subsquamosa.* Three forms from St. 2° 17′ S., 99° 56′ E., depth 613 fathoms. In specimen a, the pores are drawn, showing their small distance, and a chamber is broken open to show the structure of the toothplate, × 380.

The species occurred as well south of Sumatra (2° S., 99° E., 613 fathoms) as in the neighbourhood of Flores (10° S., 123° E., 423 fathoms). Some forms showed the typical characteristics of *Bulimina pupoides,* and some, the microspheric ones, will have been described by authors as *Virgulina subsquamosa* Egger.

In all these forms, however, the mouth, the very reduced toothplate, the texture of the shell-walls which is opaque and very finely perforated, are totally alike, and, as these same forms occur in a West-Indian species, *Cass. mexicana* Cushman, I am convinced, that these forms here belong together too.

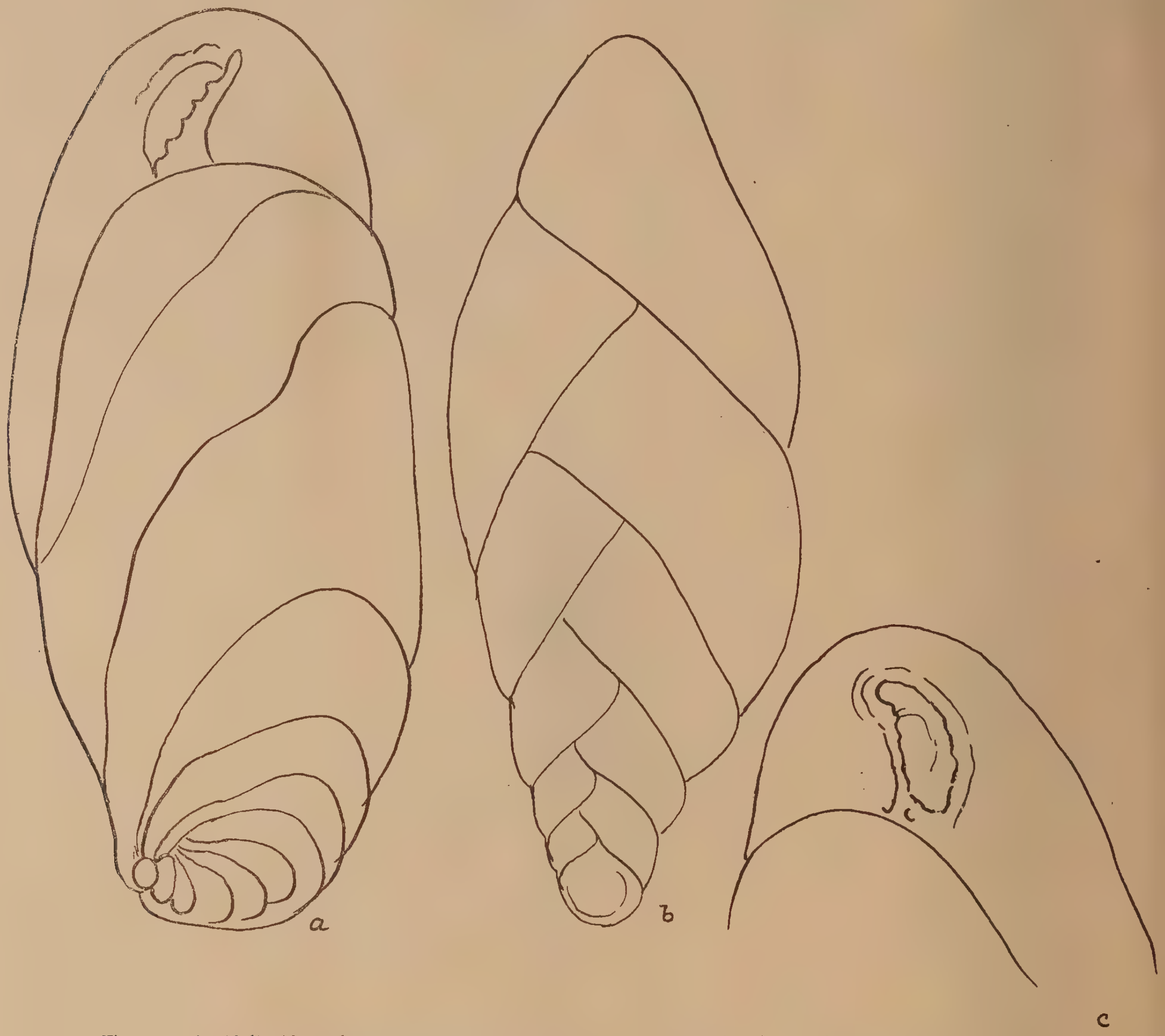


Fig. 209. *Cassidulinoides subsquamosa:* Microspheric specimen from St. 2° 17′ S., 99° 56′ E., depth 613 fathoms. a, sideview; b, from behind; c, aperture of other microspheric specimen, × 460.

Yet the statistic analysis of the species showed, that it is different from the West-Indian species, not only by its somewhat more opaque walls, but also by the somewhat other shape of the test, especially in the microspheric form, where the initial part is totally involved by the shell, so that a protruding initial end does not occur.

The B-generation begins with a proloculus with a diameter of 6-8 μ. It is directly followed by sets of biserial chambers, curling in the axis of growth, and followed by many biserial chambers in a straight arrangement. The mouth is a long oval, with one of its sides somewhat higher, with the rests of a somewhat dentated toothplate. This toothplate developes from the dorsal side of the foregoing aperture, but is very narrow and almost reduced. Number of the chambers of two specimens was 19 and 25; lengths of them 0,31 and 0,33 mm, largest breadth 0,11 and 0,13 mm. Chamber sutures distinct, chambers somewhat inflated.

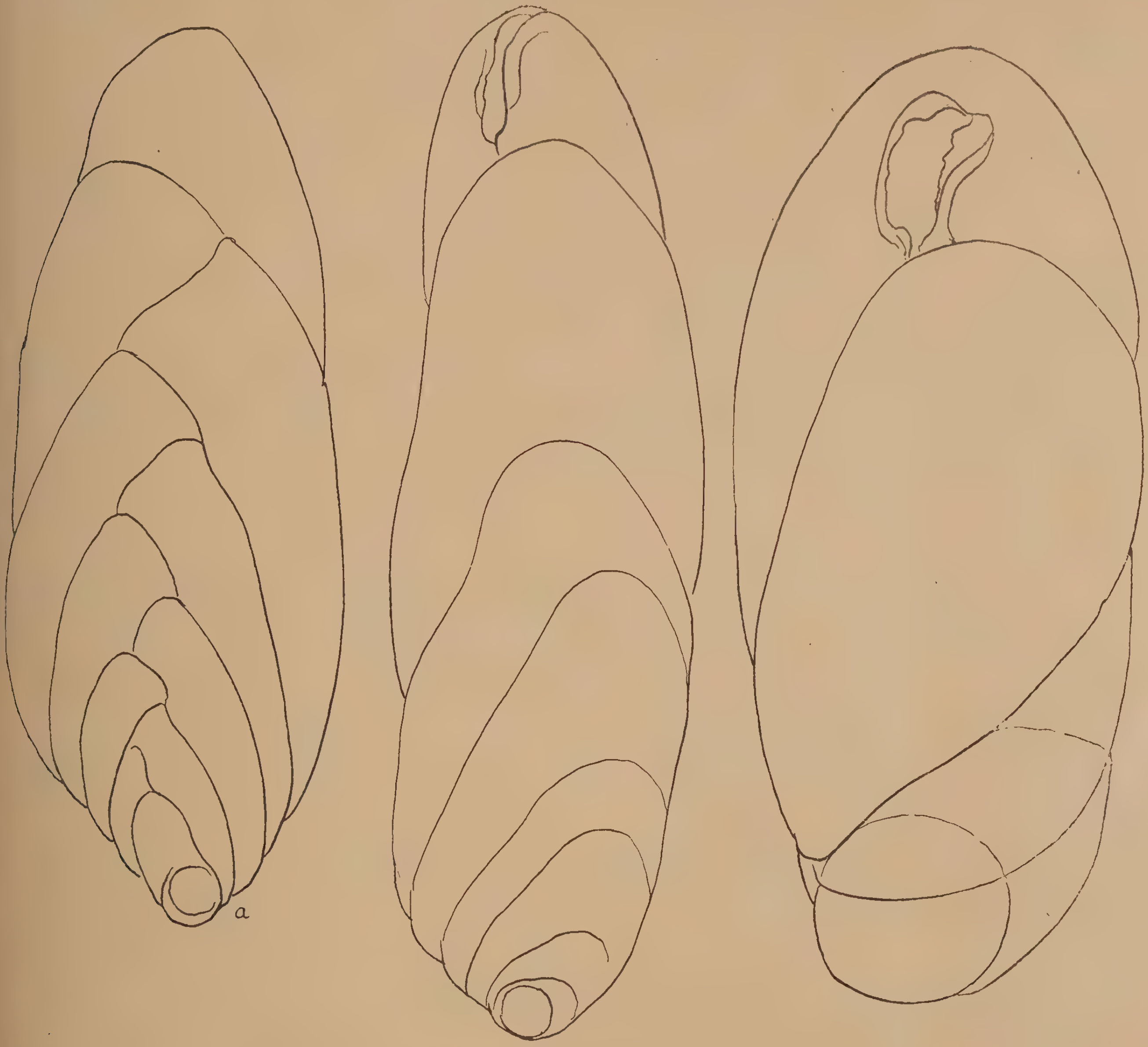


Fig. 210. *Cassidulinoides subsquamosa.* Three individuals from St. 10° 00′ S., 123° 19′ E., depth 453 fathoms, specimen a, from behind; all × 420.

The A_1-form is the more slender type, having the habitus in some cases of some *Virgulina,* but without the hyaline shell, so characteristic of that genus, and without the typical denticulated tooth of that genus. The proloculus measures in diameter from 16 up to 25 μ, and is followed by one or two sets of somewhat coiled chambers, while the next chambers show the straight biserial arrangement. The chambers are somewhat inflated, and the sutures distinct. The shell is compressed, as in some species of *Virgulina*. The mouth shows the same structure as in the B-form. Length from 0,23 mm up to 0,50 mm, breadth from 0,13 up to 0,19 mm.

The A_2-generation has a length of 0,30 to 0,50 mm. The proloculus is very large, measuring mostly about 75 μ. The total shell shows very few chambers, ranging from 5-9. The chambers are inflated and the sutures distinct. The mouth shows the normal conditions.

The statistic analysis shows without any doubt, that the Pacific species is different from that in the West-indies.

As I have chosen the rule, that a species is named after the microspheric generation, when this has already got a special name, I have called it *Cassidulinoides subsquamosa* (Egger).

In a station of the eastern part of the archipelago, in which the species was found (10° S., 123° 19′ E., 453 fathoms) a somewhat aberrant specimen was observed, which may belong to a different species as well. I have figured it in textfigure 210.

It can be distinguished moreover from the species, common in the West-Indian region by the habitus of the pores. In the West-Indian region *Cassidulinoides mexicana* shows pores, having a constant distance between each other of about 10 μ, whereas in *Cassidulinoides subsquamosa* from the Pacific the pores show a constant distance of only 2 μ.

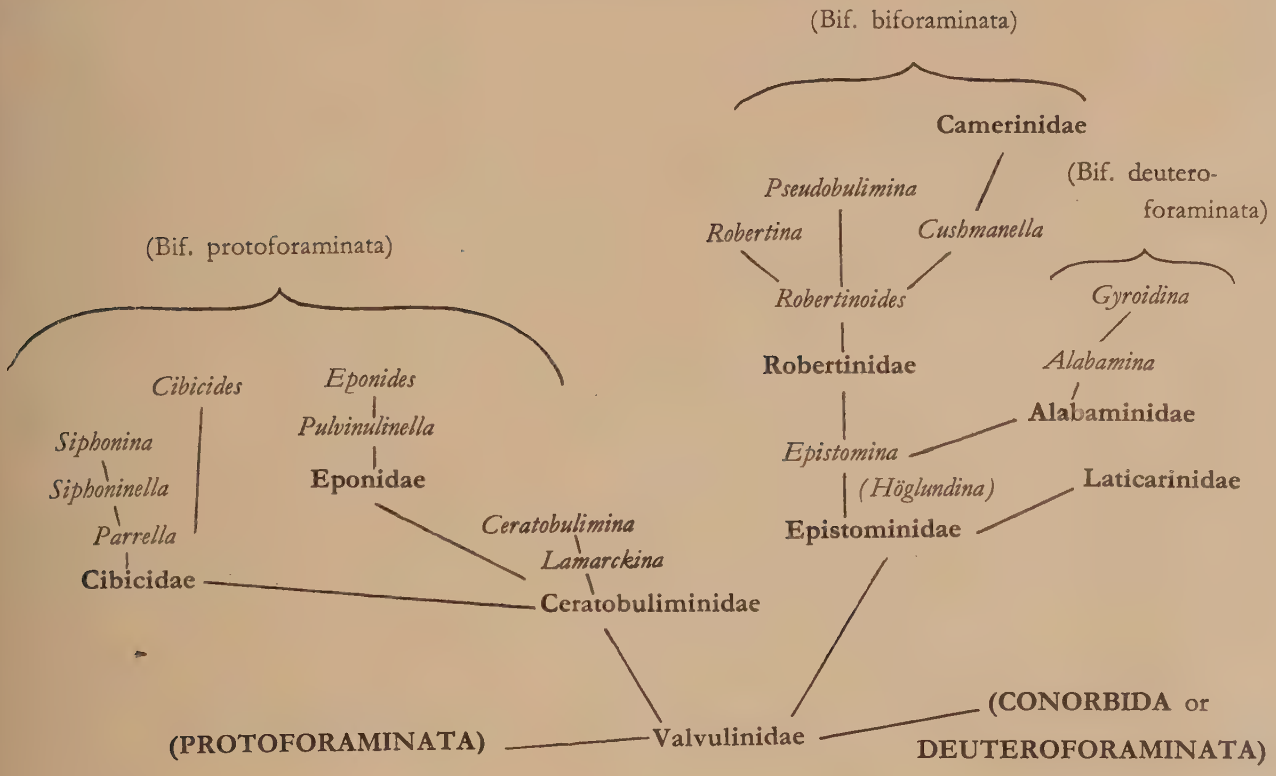
SUB-ORDO BIFORAMINATA

This sub-ordo is characterised by the possession of two foramina, as the name of it indicates. Yet its different families and genera do not always show this characteristic. In some of the lower organised genera and families there never existed a deuteroforamen, or it has been obliterated. Accordingly these genera might have been gathered in the group of the *Protoforaminata,* but for the fact, that they all are *Rotaliformes* in the sense, Brotzen employed. In some forms, as *Epistomina,* the two kinds of foramina are found together, and these forms seem to have maintained the primitive conditions of the whole group. Thus they are real *Biforaminata.* Yet in some highly advanced forms among this group, the *Camerinidae,* the protoforamen is much reduced and forms only the opening at the last-formed chamber of a typical canalsystem, the marginal chord system. In a third group the protoforamen is totally reduced, so that only the deuteroforamen is visible. These forms should be enclosed into the sub-ordo of the *Deuteroforaminata,* but for the certain fact, that they do not belong to the *Conorbida,* the main group in the *Deuteroforaminata,* but are closely allied to forms as *Epistomina,* and thus are belonging to the *Biforaminata.* So we shall separate these three groups within the *Biforaminata* as *Biforaminata s.s., Biforaminata protoforaminata* and *Biforaminata deuteroforaminata.*

In the group of the *Biforaminata s.s.* certainly are belonging *Epistomina* (*Höglundina* Brotzen), *Robertinoides* and, probably, *Robertina, Pseudobulimina, Cushmanella* and the *Camerinidae. Epistomina* shows several groups, some of which possess toothplates in all chambers, while other species absorb the toothplate in older chambers. I will not separate these two groups now, but will point to the possibility, that they form two distinct genera. So I shall distinguish the family of the *Epistominidae,* in which family may be enclosed some other fossil genera. A second family of the *Biforaminata s.s.* is that of the *Robertinidae,* enclosing *Robertinoides, Robertina, Pseudobulimina* and *Cushmanella.* A third family is that of the *Camerinidae,* enclosing many genera, as has been already analysed in my Siboga I (1927).

The groups of the *Biforaminata protoforaminata,* indicating that in these relatives to *Epistomina* the deuteroforamen has not yet developed or has been reduced in course of time, are enclosed the *Cibicidae,* with *Parrella, Cibicides, Siphoninella* and *Siphonina* (the genus *Cibicides* also comprising the so-called genera *Anomalinoides, Anomalina* and *Planulina*). A second family in that group is formed by the *Eponidae,* comprising *Pulvinulinella* and *Eponides.* A third family is formed by the *Ceratobuliminidae,* in which family are gathered the genera *Lamarckina* and *Ceratobulimina. Lamarckina* without doubt is a protoforaminate Foraminifer, whereas the situation as to the state of the aperture of *Ceratobulimina* is not yet totally cleared up.

Sub-ordo **BIFORAMINATA**


(Bif. biforaminata)
Camerinidae
(Bif. deutero-foraminata)
Pseudobulimina
Robertina
Cushmanella
(Bif. protoforaminata)
Robertinoides
Gyroidina
Robertinidae
Alabamina
Cibicides
Eponides
Alabaminidae
Siphonina
Pulvinulinella
Epistomina
Siphoninella
Eponidae
(Höglundina)
Laticarinidae
Parrella
Ceratobulimina
Epistominidae
Lamarckina
Cibicidae
Ceratobuliminidae
(CONORBIDA or
(PROTOFORAMINATA)
Valvulinidae
DEUTEROFORAMINATA)

The third group, that of the *Biforaminata deuteroforaminata,* is comprising all those forms, in which the protoforamen is obliterated. Here the genera *Alabamina* and *Gyroidina* form the family of the *Alabaminidae,* whereas *Laticarinina* forms a family apart, the *Laticarinidae.*

Closely related to the *Biforaminata* are the ancestral forms of the *Deuteroforaminata,* especially the genus *Conorbis* from Jurassic time on. It is doubtful, whether *Conorbis* or *Lamarckina* or even *Epistomina* were the mother-forms of these two Sub-ordines. Yet it may be, that they originated independently from the *Valvulinidae.* Fact is, that the *Deuteroforaminata* always show a deuteroforamen, marginally placed from a protoforamen, with a lip toward the umbilical hollow between, and that this umbilical hollow nearly always is present in this sub-ordo, whereas in the Sub-ordo of the *Biforaminata* this umbilical hollow is not present in the more primitive forms, and has only secondarily developed in some advanced groups, in *Cibicides* (*Anomalina, Planulina*) and in some genera of the *Camerinidae* (*Operculina*).

Most of the *Biforaminata* show an opaque wall, often of brownish or yellowish colour, and nearly always with protopores. Only in some advanced groups the wall may become hyaline (*Camerinidae, Laticarinina, Eponides*) and the pores may have developed into deuteropores (*Cibicides, Alabamina verrucosa*).

The scheme will clear up the relationship of the different families and genera, belonging to the *Biforaminata.*

The toothplate of the *Biforaminata*

(Fig. 211)

Once more in this sub-ordo the toothplate may be drawn into the centre of discussions, as its development, its place in regard to the foramina and its reduction show to be of high systematic value.

This plate in this group in the central families, the *Ceratobuliminidae,* the *Epistominidae* and the *Robertinidae,* has developed its utmost specialisation, whilst in the *Camerinidae* it has formed the marginal chord system. This, however, I will clear up in another paper about the West-Indian Foraminifera, when dealing with the genus *Cushmanella.* In *Laticarinina* it has formed the carina, whereas in the *Alabaminidae,* the *Eponidae* and the *Cibicidae* it has been more or less reduced. Yet in those reduced states it is of high importance, as only the place of the toothplate gives us a clue as to the homology of the foramina.

In the genus *Lamarckina* the toothplate is always a low, not very well developed plate, which shows the peculiarity to be already existent before the next chamber is formed. This indicates the primitive status of the genus, as it reminds us of the state of the toothplate in de *Valvulinidae,* as in that family it is a valvular plate over the aperture, partly covering that aperture. This is likewise the case in *Lamarckina,* in which genus the plate forms a covering plate over the aperture and partly over the umbilicus. This structure reminds us too of the *Deuteroforaminata,* especially of those groups in that sub-ordo, in which a distinct plate is covering parts of the umbilicus. So it may be, as I will point out, when dealing with that sub-ordo, that the toothplate of *Lamarckina* and the covering apertural plates of forms as *Discopulvinulina,* are homologous things. In *Lamarckina* often the toothplates in older chambers are absorbed, but in microspheric specimens as well as in Lower Cretaceous species, they may remain also in older chambers.

In *Ceratobulimina* it is already highly specialised. In that genus there has been described also a covering "plate" over the aperture; this plate, however, shows fine protopores, and thus cannot be homologous with the toothplate of *Lamarckina.* It is part of the chamberwall and has nothing to do with the toothplate. This plate is found within each chamber, and consequently is formed together or after the chamber itself has been formed. This status indicates a higher development of the genus, in regard to that of *Lamarckina.* In *Ceratobulimina* it is a large and broad plate, attached to the distal border of the former (septal) foramen and running to the opposite border of the next one. Its free folded part often shows a distinct development of a ventral outgrowth, but not in Miocene *Ceratobulimina contraria.* The plate is attached to the marginal part of the chamberwall, with a distinct suture, running obliquely from the chamber-suture, and showing some resemblance to the suture, found at the marginal border of the protoforamen of *Epistomina.*

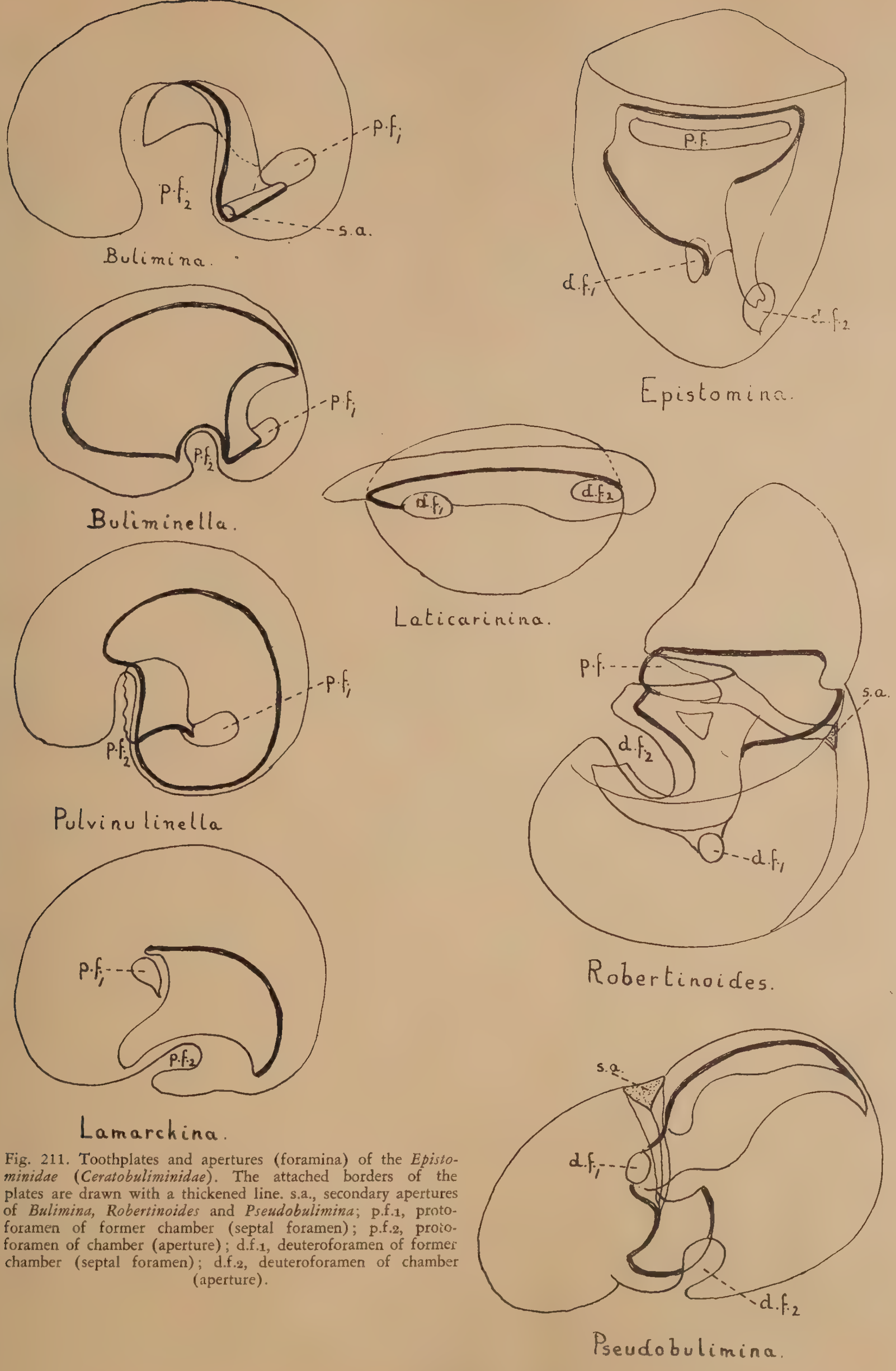

p.f.1
p.f.2
s.a.
Bulimina.
p.f.
d.f.1
d.f.2
Epistomina.
p.f.1
p.f.2
Buliminella.
d.f.1
d.f.2
Laticarinina.
p.f.1
p.f.2
Pulvinulinella
p.f.
s.a.
d.f.2
d.f.1
Robertinoides.
p.f.1
p.f.2
Lamarckina.
s.a.
d.f.1
d.f.2
Pseudobulimina.

Fig. 211. Toothplates and apertures (foramina) of the *Epistominidae* (*Ceratobuliminidae*). The attached borders of the plates are drawn with a thickened line. s.a., secondary apertures of *Bulimina, Robertinoides* and *Pseudobulimina*; p.f.1, protoforamen of former chamber (septal foramen); p.f.2, protoforamen of chamber (aperture); d.f.1, deuteroforamen of former chamber (septal foramen); d.f.2, deuteroforamen of chamber (aperture).

This fact in some respect points to the supposition, that at this suture originally a protoforamen may have been formed; in that case *Ceratobulimina* should not be enclosed in the *Ceratobuliminidae,* together with *Lamarckina,* but together with *Epistomina.* Intermediate stages have not been found yet, and thus this question cannot be cleared up.

In *Epistomina* the toothplate shows in main characters the form of that, found in the *Protoforaminata.* It has an attached part and a free folded part. The attached part runs along the proximal chamberwall, leaving free a short part before it reaches the next protoforamen, and then it is attached to the marginal border of that marginally placed protoforamen. In Jurassic species, such as in *Epistomina stelligera,* the protoforamen is short, and consequently the toothplate is relatively narrow, its free folded part is narrow too and not highly developed. But in later species it becomes much more developed, especially in regard to its free folded part. For, after running along the marginal border of the protoforamen, it forms a curved suture at the distal side of it, and then becomes a free plate, folded backward. This free folded part runs toward the next deuteroforamen, but does not attach itself to its border.

In *Pulvinulinella* the toothplate once more is of a simple type, resembling that of *Cassidulina* among the *Protoforaminata.* Its attached part here forms a large part of the ventral chamberwall too, as is the case in *Buliminella*-species.

In the forms typically adapted to pelagic life, such as the *Robertinidae,* the development of the toothplate reaches its highest complication. Here the main part of the plate is developed as in *Epistomina,* with a broad attached part, dividing the chambers into two parts; but the attached part in these genera develops a structure, also found in higher developed *Bulimina*: a canal-shaped structure, giving rise to supplementary apertures. In *Robertinoides* and *Pseudobulimina* one canal and a single supplementary aperture is formed in this way, but in *Cushmanella* two of them are formed, symmetrically arranged in respect to the protoforamen. In older chambers these supplementary apertures are closed by small porous plates.

In *Laticarinina* the toothplate runs from the former deuteroforamen towards the margin of the chamber, towards the place, indicated in *Epistomina* as the protoforamen; but this foramen here is closed, and the toothplate runs through this place into the outer world, thus forming a broad keel at the margin.

Among the *Alabaminidae* the toothplate in *Alabamina* is indicated by a grove in the apertural face, marginally placed in respect to the aperture. This indicates directly, that the aperture is a deuteroforamen. Whether the grove in the apertural face is the rest of a protoforamen, or that the protoforamen never was present, cannot be concluded with certainty, though Brotzen made it very probable, that the grove is the rest of a protoforamen. In *Gyroidina* the toothplate is yet more reduced than in *Alabamina* and is only indicated at the inner side of the chamberwall. As in that genus the foramina are always placed distally from those rests of toothplates, these foramina are without doubt deuteroforamina, and thus the genus *Gyroidina* belongs in this deuteroforaminal group (*Biforaminata deuteroforaminata*).

At the other hand in the protoforaminate group of this sub-ordo, the genus *Pulvinulinella* clearly shows, that the septal foramina are protoforamina; the simple toothplate here often is very much reduced. In *Eponides* this reduction is much more developed, and thus the toothplate is scarcely visible. But the place of the very much reduced plate, together with the loop-shape of the foramina, clearly indicate that here too the foramina are protoforamina. In the genus *Parrella,* the toothplate is of the same simple texture, as found in *Pulvinulinella.* Here too the foramina are protoforamina, as the toothplate is attached to their borders. In several species of *Parrella* indications are found, that the protopores in this genus may develop into deuteropores. It is therefore, and in respect to the fact, that the foramina of *Cibicides* and *Siphonina* are found in a situation, resembling that of *Parrella,* that these genera have been placed in the *Cibicidae* together.

Special attention has to be given to the situation of the chambers in the genera *Robertinoides* and *Pseudobulimina,* in relation with that in *Epistomina.* Presuming, that in *Epistomina* the situation of the chambers in respect to the proloculus is the normal one, we find, that the protoforamen is situated proximally, and the deuteroforamen distally from the proloculus. But then the chamber of *Robertinoides* has to be studied in a reverse position compared with the common use. For in all older works *Robertinoides* is figured with the initial part down; since in *Epistomina* we are used to draw the initial part above, and then in *Robertinoides* the slit, usually called the secundary aperture, is the protoforamen, whereas the larger aperture, now situated distally from the proloculus, is the deuteroforamen. This agrees fully with the structure of the toothplate. This plate is, in this position, attached proximally to the protoforamen, as in *Epistomina,* whereas its free folded part runs toward the deuteroforamen. The attached part shows in its suture a short distance, in which it is not attached to the outer wall of the chamber; this spot is also found in *Epistomina*; here it forms the opening between the main (distal) chamberpart and the smaller (proximal) chamberpart. These two parts can also be observed in *Epistomina,* but here the proximal part is much smaller than that of *Robertinoides.* While in *Epistomina* the attached part is a simple one, in *Robertinoides* it becomes folded, and forms the typical canal running from the protoforamen towards the supplementary aperture at the backside of the chamber. This canal is indicated already in *Epistomina* by the curved suture round the protoforamen.

In *Pseudobulimina* the chamber is reverted, so that the protoforamen is closed between the two chamberparts. The supplementary aperture thus gets a proximal position, and the toothplate is folded in a very complicated way. In *Cushmanella* the toothplate has become symmetrically built, according to the planospiral coiling of the test. It may be, that *Cushmanella* even is a very primitive form, but very little is known about its fossil state, due to the thin test.

The textfigure 211 may clear up the statements, just mentioned. The attached borders of the toothplates in the different groups have been drawn with a heavy lining. The figures of *Bulimina* and *Buliminella* are given for comparison.

Geographic distribution

Lamarckina scabra. Madura-bay and Strait Molo. Border between eastern and western part, but still in the western part.

Pulvinulinella exigua. South of Sumatra, western part.

Epistomina elegans. All over the area.

Laticarinina pauperata. South of Sumatra, western part.

Ceratobulimina pacifica. South of Sumatra, western part.

Robertinoides oceanica. In both parts of the Archipelago.

Pseudobulimina convoluta. Western part.

Alabamina verrucosa. Western part, up to the border of it.

Alabamina procera. Western part.
Parrella rotaliformis. Western part.
Parrella culter. South of Sumatra, western part.
Siphonina reticulata. In both parts of the Archipelago.
Gyroidina soldanii. Both areas.
Gyroidina tenera. Both areas.
Eponides repanda. Western part.
Cibicides akneriana. Both areas.
Cibicides wuellestorffi. Both areas.
Cibicides margaritifera. Western part.
Cibicides mundula. Western part.
Cibicides ammonoides. Western part.
Cibicides flintii. Western part.
Cibicides aequipunctata. Western part.
Cibicides ungeriana. Both areas.
Cibicides hyalina. Both areas.

So the distribution of the *Biforaminata* is mainly restricted to the western part of the Archipelago; only *Epistomina elegans, Robertinoides oceanica* and *Siphonina reticulata* were found too in the eastern part; *Robertinoides* seems to be a pelagic species, *Epistomina elegans* is a species, found in all tropical seas and seems to be an ancient species too. *Siphonina reticulata* was rarely met with.

Though *Pulvinulina exigua* seems to be a pelagic species, it was restricted to the western part. Similar species occur in the Atlantic area but are not identical with the species.

Lamarckina scabra was not mentioned by Cushman from the Philippines.

Pulvinulinella exigua was found rarely at Palawan Passage, Philippines.

Epistomina elegans was found over the whole area of the Philippines, as well as southwards on in many parts of the eastern part of the Malay Archipelago by Cushman.

Laticarinina pauperata was found in several East Indian stations by Cushman, ranging from 4° N to 4° S., and from 118° E. to 128° E., thus occurring too in the eastern part. So it occurs in reality in both parts of the area, together with *Epistomina,* to which it is related.

Ceratobulimina pacifica, mentioned as *Buliminella contraria* by Cushman in 1921, was found rarely by him in the Molucca-Passage, so at the border of the eastern part, but not southward on. So it seems restricted to the western part of the Archipelago.

Alabamina procera was found by Cushman in many stations in the Philippines, but not southward from 4° N. So it does not occur in the Australian region.

Parrella culter was found by Cushman in a single specimen off Buro Island; this single record seems somewhat doubtful.

Siphonina reticulata was rarely found in some Philippine stations, but not southward on. I found it always in rare specimens.

All these records show, that most species of the *Biforaminata* are restricted to the western area, and that only very few species are found too in the eastern part; no species is restricted to the eastern part only.

Family *Ceratobuliminidae*

This family includes here the genera *Lamarckina* and *Ceratobulimina*. In both genera it seems, that the single aperture and foramen is a protoforamen, though in *Ceratobulimina* there is a slight doubt about it.

The family is characterised by smooth and relatively thin walls, except for the dorsal walls of *Lamarckina,* which mostly are ornamentated by irregular pustules. The texture of the walls always is opaque and the pores always are fine protopores. The chambers in both genera form a short spiral, always soon the chambers increase in size, so that the spiral is slightly contorted. The aperture in both genera is loop-shaped and sunken down; in *Lamarckina* the aperture is always covered by a toothplate partly covering the umbilicus also, whereas in *Ceratobulimina* the side of the aperture is partly closed by an outgrowth of the wall itself, whereas the toothplate is a complicated structure within the chamber.

The family reaches down at least into the Lower-Cretaceous.

Genus **Lamarckina**

This genus is with certainty known to me from the lower Cretaceous on upward. These Lower-Cretaceous species are more elongate than those, found in the Tertiary and in recent times. They show more primitive toothplates too. The shape of their toothplate indicates their relationship with *Valvulinidae* without doubt.

In the Tertiary the genus has not altered much. Many species are known, in which the convex dorsal side (spiral side) is covered with irregular pustules, indicating, that this side in life is the upper side, whereas the umbilical side always is smooth and even shiningly polished. In the umbilical hollow in all species, known to me, small pointed pustules are found, always directed toward the apertural opening. These pustules may indicate, that a part of the protoplasm, functioning as an attaching medium, is strengthened by these pustules.

In all species known the toothplate is formed formerly to the next chamber. This characteristic also indicates a strong relationship with the *Valvulinidae,* in which family the toothplate always is found at the border of the last-formed aperture, and not only at that of the former aperture.

Typical for the genus is the small number of chambers, forming the coiled test, and consequently few whorls are formed. In many species the test is formed by 1½ whorl. The chambers rapidly increase in size and are overlapping at the ventral side, so that the umbilical hollow is often partly closed by them; this closing is completed by the toothplate. This plate at its free border often shows irregular dentations. The pores in the tests are always protopores, very fine, and distributed all over the surface. The walls are always of an opaque structure, and always yellowish in colour, in recent as well as in fossil species.

Lamarckina scabra (Brady)
(Fig. 212, 213)

The species occurred only in two specimens which were, however, very well preserved, and both megalospheric, in Station 51, in a depth from 69 to 91 m., Madura-bay and Molo-strait.

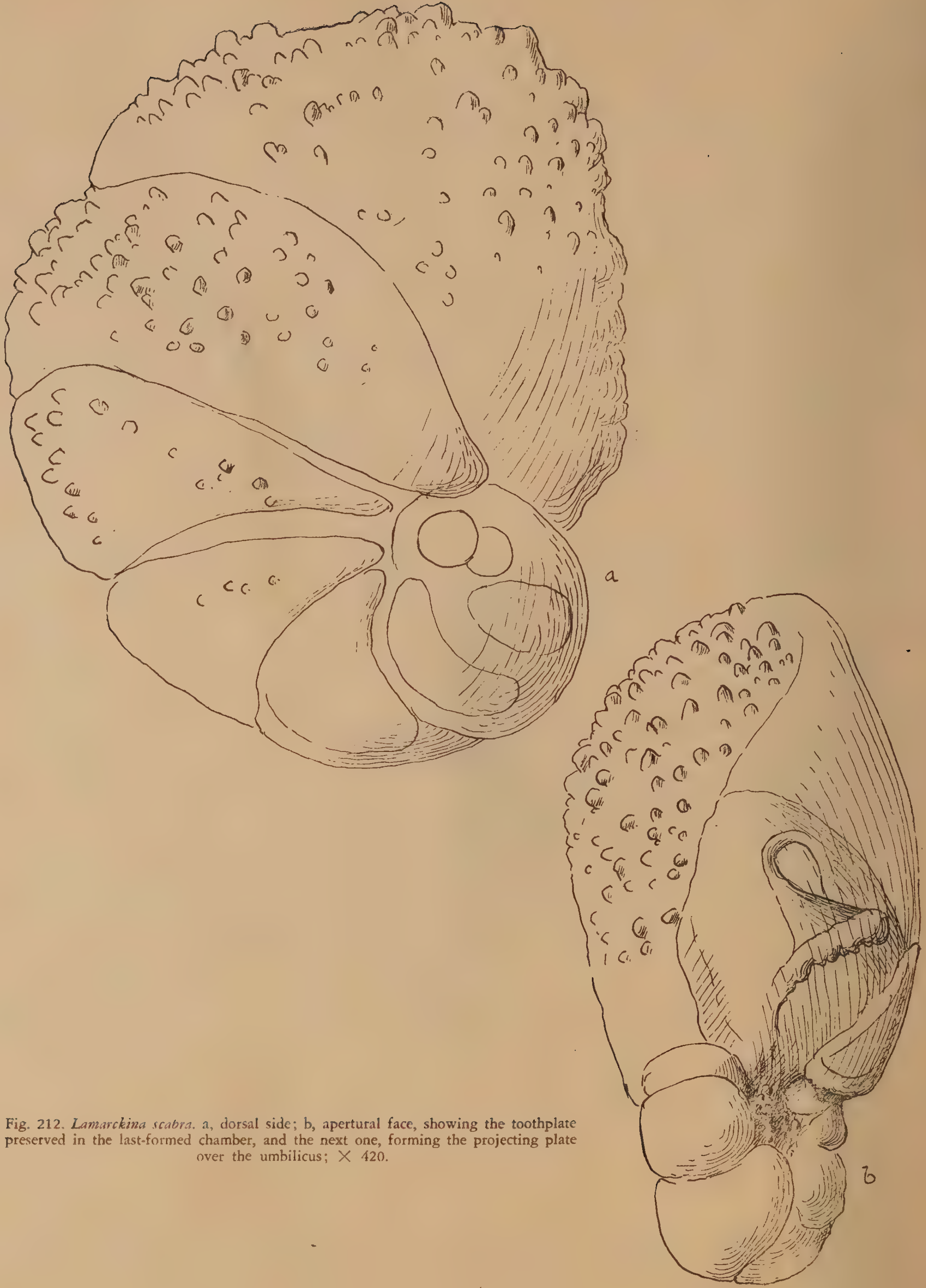


Fig. 212. *Lamarckina scabra.* a, dorsal side; b, apertural face, showing the toothplate preserved in the last-formed chamber, and the next one, forming the projecting plate over the umbilicus; × 420.

When measured and studied for their structure, it turned out, that they do not differ in whatever respect from those which are found in the West-Indian region. These have been called by Cushman with a different name, *L. atlantica,* and so I am convinced, that this is nothing but a synonym for *L. scabra.*

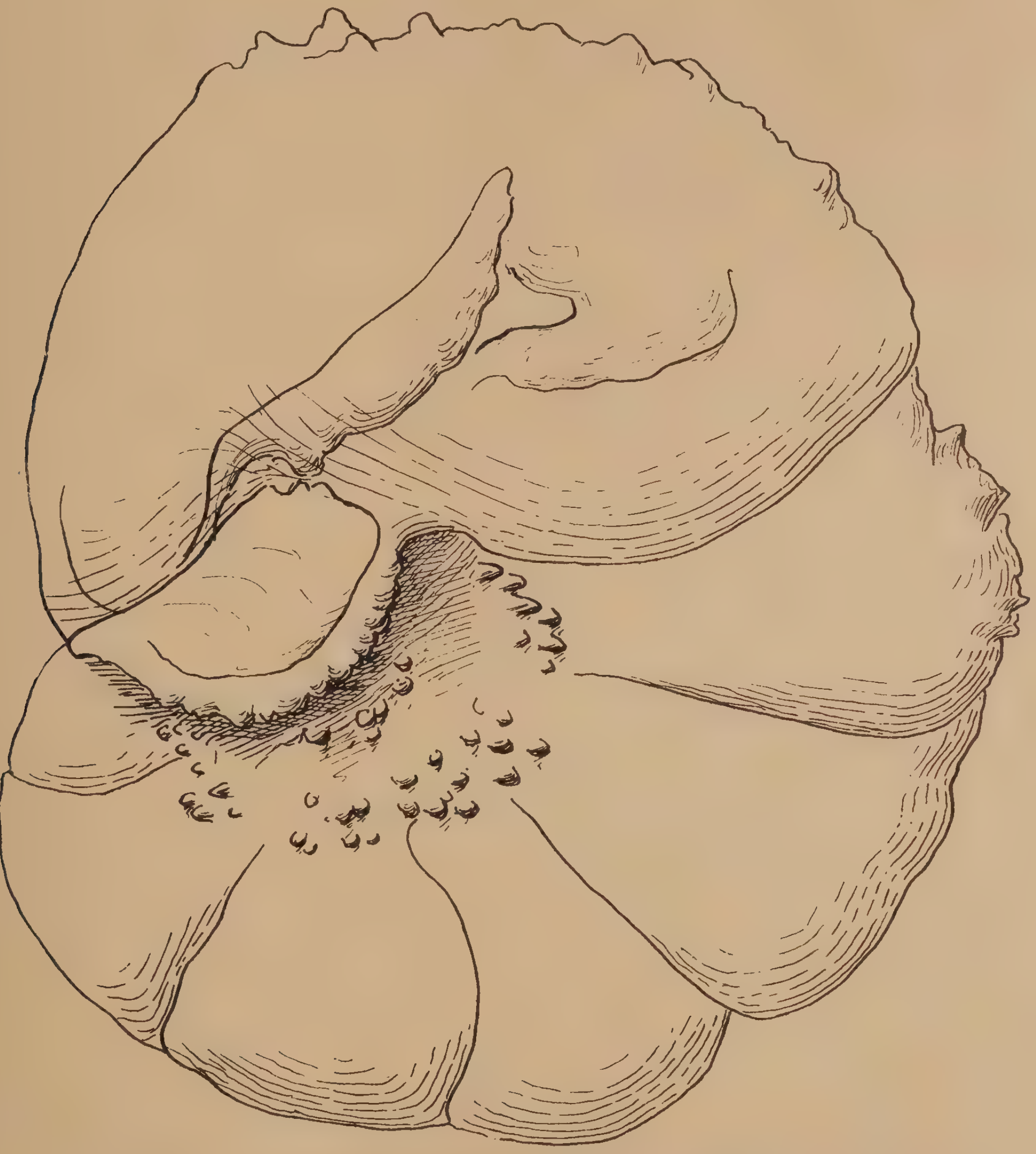


Fig. 213. *Lamarckina scabra.* Ventral side of individual of textfig. 212, showing the typical pustules in the umbilicus, the covering next toothplate, and the former toothplate in the last-formed chamber. × 480.

In one of the individuals not only the toothplate covering the umbilical region was present, but also the toothplate in the last-formed chamber occurred. As the latter showed quite the same characteristics of the plate, covering the umbilicus, as in a microspheric specimen from the West-Indian region which I found with its toothplate well-preserved, there is no doubt as to the real structure and nature of the covering plate: it is the toothplate of the chamber, which will be formed later.

The proloculus of both individuals measured 25 μ, thus indicating them to be the A_2-generation. This was in agreement with the structure of the dorsal side, as it was covered with many short spines. The total number of chambers was 8 and 9 (See my paper on West-Indian Foraminifera).

Genus **Ceratobulimina**

This genus is characterised by the very short spiral, the rapidly increasing inflated chambers, the large loop-shaped aperture, which is partly closed at one side by an outgrowth of the chamberwall, and the very complicated toothplates in all of the chambers. The different species known, most of them fossil, are only slightly differing from each other. The walls are always opaque, yellowish-brown and provided with very fine protopores. Walls always smooth and shining.

Ceratobulimina pacifica Cushman et Harris
(Figs. 214-218)

This species occurred in many specimens in gatherings near 2° S. and 99° E. It was found at depths ranging from 460 up to 977 fathoms. The species did not occur in the samples from the Flores-sea.

The microspheric form was found in two specimens, length 0,38 and 0,43 mm, breadth respectively 0,31 and 0,29 mm. Proloculus diameter 10 μ. The proloculus was followed by 16 and 17 chambers, the angle of the attached part of the toothplate with the suture was 60° and 30°. One specimen had a proloculus of 6 μ diameter and showed 23 chambers.

The A_1-form begins with a proloculus, with diameter ranging from 17 up to 28 μ, with a top at 25 μ. From the 29 specimens gathered of this generation some were typical young ones, most had a length of 0,31 up to 0,38 mm, with a breadth of 0,25 up to 0,28 mm. Some few specimens however were longer and broader. The average number of chambers in the main group was 12. The first two chambers are surrounded by a somewhat thicker wall, thus pointing to an embryo with two chambers.

The third generation may be formed by many specimens, with proloculus-diameter from 25 up to 40 μ, but it may be also, that this generation is not a distinct generation in these gatherings. The number of chambers was 10 in average, length 0,14-0,35 mm.

Special study was made of the inner structure of the shell. The sutural (septal) foramen is small, and is situated above the ventral margin of the chamber and somewhat obliquely to it, but always in a vertical direction to the umbilical side of the shell. Ventrally from it a very peculiar toothplate runs to the opposite dorsal side of the next foramen. This toothplate shows a free edge, in all cases projecting somewhat retrograde, here developed in a large flange, provided with irregular teeth which point towards the umbilical wall of the chamber. This large flange had to be supported, and therefore the base of the edge of the plate attaches itself to the dorsal side of the chamberwall, which attachment begins at the suture, and runs with an edge, typical for the species, toward the middle of the chamberwall. The point, at which this support attains the suture, lies just above the place, where the foramen is situated. The toothplate runs to the dorsal side of the next aperture and adheres here in the neighbourhood of its dorsal side, running along one of its sides as a second support of the flange. The aperture itself is sunken down in a longitudinal ridge of the apertural wall, giving rise to a typical Buliminine opening. But, as Höglund (1947) has pointed out already for the *Buliminidae*, the toothplate forms near the aperture a typical curve, thus giving rise to a small opening of the chamber into the umbilical hollow. Thus two openings of the chamber are formed, the one the septal aperture, the other the umbilical opening formed by the toothplate. The latter opens into the lumen of the chamber underneath the denticulated flange. On the ventral part of the wall of the former chamber a row of sharp and pointed pustules has been formed, and these teeth can be observed in the umbilicus of an unbroken shell too. It may be, that the flange with its dents and the pointed pustules make the protoplasm stream in the direction of the umbilicus, thus suggesting, that *Ceratobulimina* lives a somewhat attached life (see figs. 215-217).

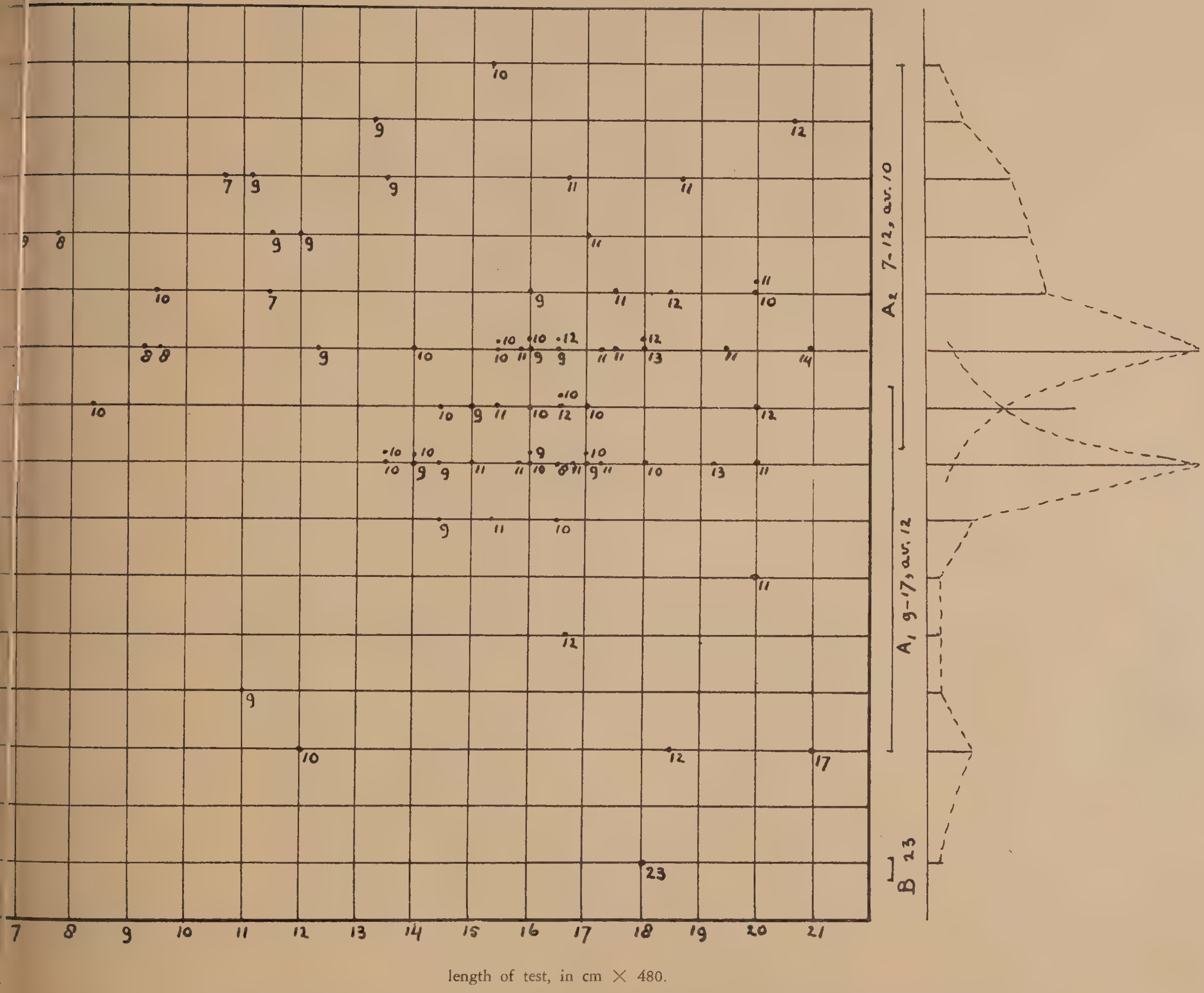


Fig. 214. *Ceratobulimina pacifica.* Diagram of relation between length of test and size of proloculus. The figures reveal the number of chambers. The curve of megalospheric tests shows two tops. These curves may be overlapping ones.

The outer surface of the shell is smooth and shining, the pores are very fine.

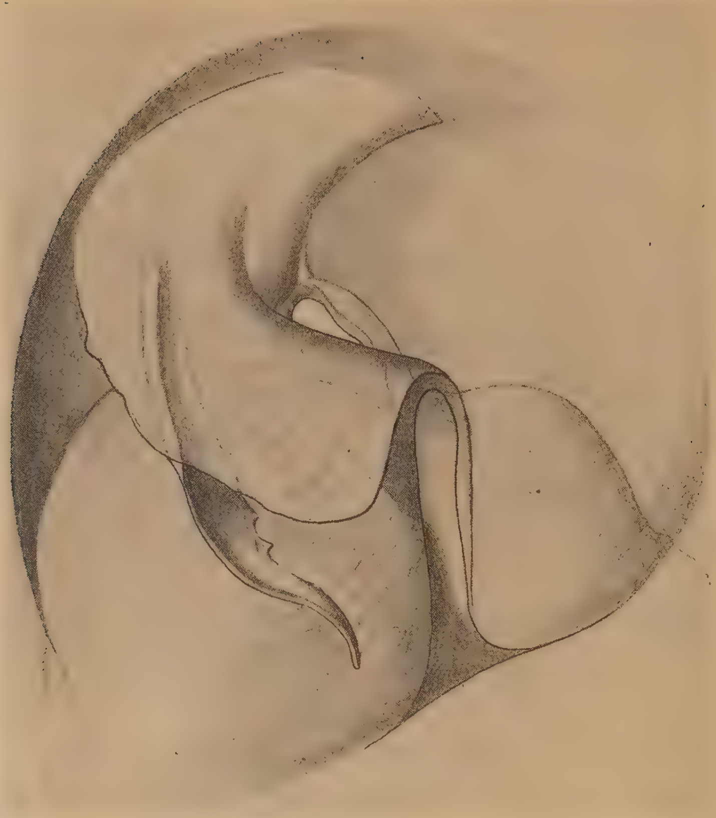


Fig. 215. *Ceratobulimina pacifica.* Whole chamber, seen from aperture, with the toothplate; the septal foramen is partly seen behind the toothplate. Glassplate-drawing.

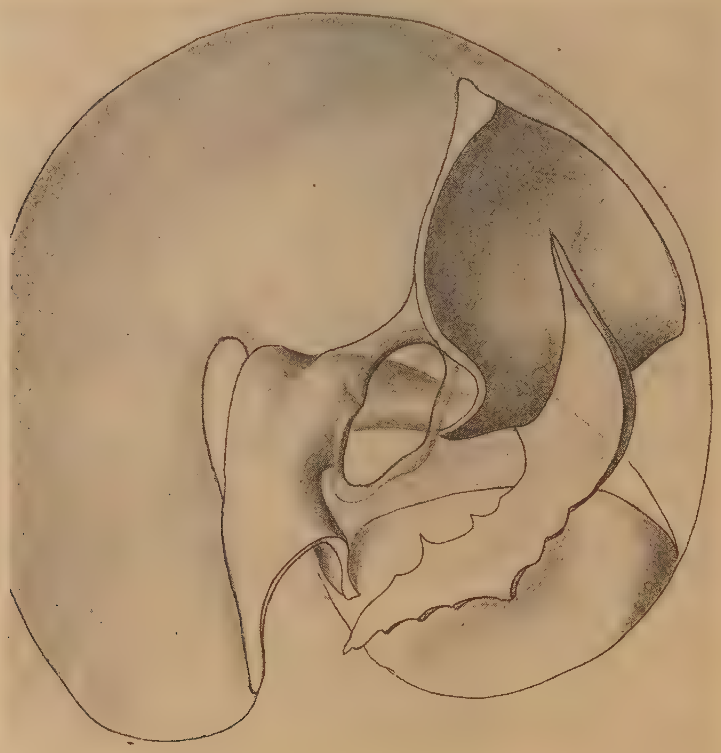


Fig. 216. *Ceratobulimina pacifica.* Last-formed chamber, from behind, showing septal foramen, toothplate with folded part over the next aperture, attached part running toward the marginal wall, with extra flaring part below. Glassplate-drawing.

Ceratobulimina with its toothplate and its buliminine aperture thus is a typical genus, closely allied to *Lamarckina* and *Epistomina.*

The structure of the toothplate, clearly shown in glass-plate drawings, indicates, that the attached part which forms a distinct suture with the outer wall on the dorsal (marginal) side of each chamber, is comparable with the attached part of the toothplate at the upper border of the proforamen of *Epistomina.* But in *Ceratobulimina* the proforamen is closed and only its foremost part remains, forming the aperture. To this aperture the toothplate is directed mainly with its free folded part.

Cushman and Harris describe the species:

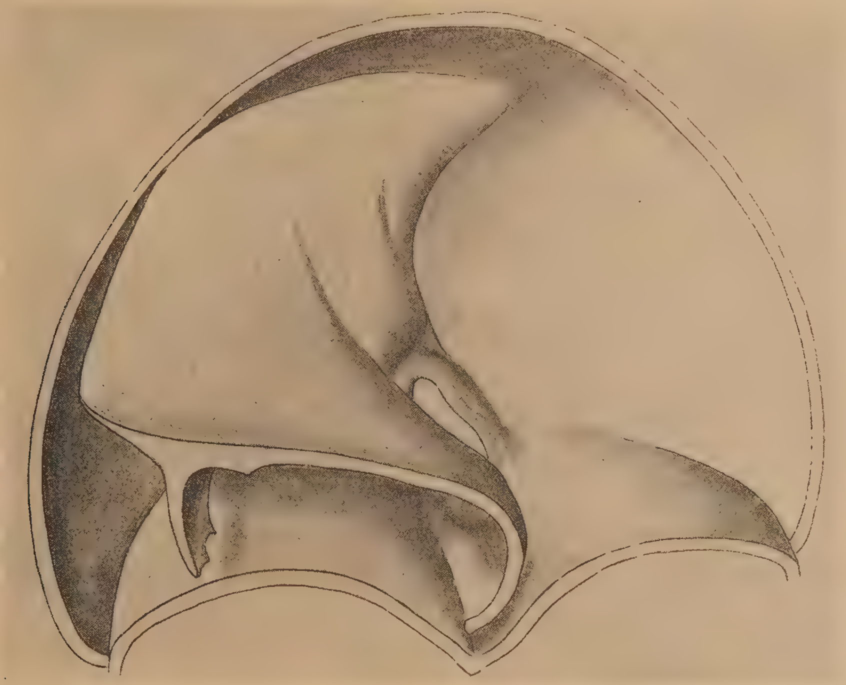


Fig. 217. *Ceratobulimina pacifica.* Section through last formed chamber, ground down from apertural side, showing toothplate with its attached upper part. Glassplate-drawing.

"Test nearly as broad as long, periphery very broadly rounded, the last chambers becoming somewhat involute on the dorsal side; usually 6 chambers in the last-formed whorl; sutures distinct, very slightly depressed; aperture narrow elongate, narrowing toward the middle of the face. Length 0,90 mm; breadth 0,65 mm; thickness 0,40 mm."

They found it at the coast of Mindanao.

As in many *Biforaminata,* the aperture is loop-shaped in its main character. The protruding border has the shape of a plate, with sawed edge, whereas the dorsal (proximal) border is sunken down, as in most loop-shaped apertures. The sawings of the protruding border begin underneath the spot, where the toothplate is attached to the wall, which spot can easily be seen from the outside as a fine but distinct and short suture. This suture may be the rest of a protoforamen, whereas the main aperture is the deuteroforamen. But the fact, that the aperture is loop-shaped, which is the more clear when observing the shape of the septal foramina, deriving from this aperture, points to

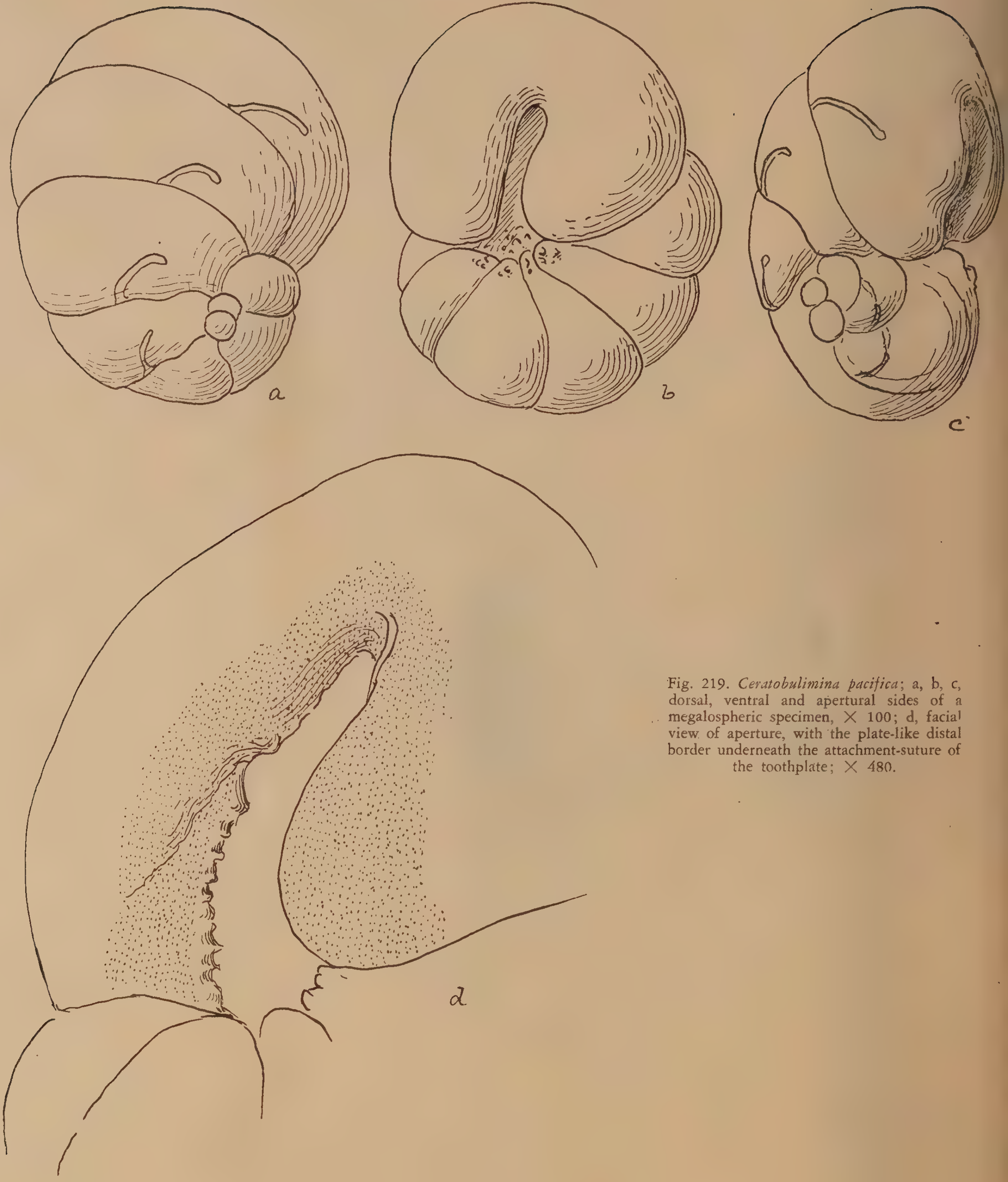


Fig. 219. *Ceratobulimina pacifica*; a, b, c, dorsal, ventral and apertural sides of a megalospheric specimen, × 100; d, facial view of aperture, with the plate-like distal border underneath the attachment-suture of the toothplate; × 480.

its protoforaminal nature. So this question is not yet cleared up, and previously I have placed therefore the genus in the protoforaminate group.

Cushman has described the protruding border of the aperture as a distinct plate, when he writes:

"In perfect adult specimens the aperture covered by a thin convex plate merged with the chamberwall above the aperture in a semicircular line, the lower end thin, lip-like." But this plate has nothing to do with a plate like that of Lamarckina; it is nothing but the protruding border of the loop-shaped aperture, a part of the outer chamberwall, and thus is pierced by pores just like the other parts of the chamberwalls. It is no plate at all, but the border of the aperture itself, as is shown by those pores. (Cushman, Contr. Cushman Lab., Vol. 3, pt. 4, 1927, p. 172).

Family *Eponidae*

This family includes here the genera *Pulvinulinella* and *Eponides*. From these genera *Pulvinulinella* is the primitive one, as it always shows a more or less reduced toothplate. The aperture is loop-shaped, and situated riding on the ventral suture, but always near the margin. A more or less large part of the ventral wall of each chamber shows no pores, and the very hyaline and thin walls are for the rest covered with fine protopores. The tests show a relatively short spiral, coiled up along a very short axis. At the dorsal side all chambers are visible, at the ventral side the chambers are largely overlapping, leaving no umbilicus at the centre. Margina always rounded. In the genus *Eponides* the aperture in most cases is very small, but still shows the characters of a protoforamen, and a deuteroforamen does not exist in both genera.

The difference between *Pulvinulinella* and *Eponides* mainly lies in the reduction of the toothplate in *Eponides*. As in *Eponides* the toothplate is more reduced than is the case in *Pulvinulinella*, one would suggest, that *Eponides* is a younger genus, in regard to *Pulvinulinella*. But records of *Eponides* are found from the Jurassic on. Yet I could state, that many species, called *Eponides*, in reality are species of the genus *Alabamina*. So species from Jurassic and Cretaceous should be restudied as to their inner structure. May be that they will reveal that they belong to other genera, and not to *Eponides*.

Genus **Pulvinulinella**

There are many fossil records of *Pulvinulinella* which have to be restudied as to their inner structure. But recent *Pulvinulinella* seems to be a pelagic genus. Here the walls always are very thin and shining. The pores always are protopores, and very fine. The spiral is a short one and the chambers are overlapping at the ventral side, reaching the centre. No umbilicus. Aperture a loop-shaped opening on the ventral suture near to the margin, with a more or less developed toothplate in the chamber, always attached to the ventral border of the aperture. This aperture is not situated along the suture, but riding on it, as in *Ceratobulimina*. Part of the wall underneath the aperture formed by the toothplate and poreless. There exist several distinct species in recent oceans.

Pulvinulinella exigua (Brady).
(Figs. 219-221)

This small species occurred in several deep samples, and was especially numerous at 2° 26′ S., 99° 35′ E., depth 582 fathoms, bottomtemp. 6,6° C.

This species has been described fully by Cushman already, e.g. in his Foraminifera of the Atlantic Ocean, U. S. Nat. Mus. Bull. 104, pt. 8, 1931, p. 44-45 as follows:

"Test small, almost equally biconvex, peripheral margin bluntly rounded, often lobulated; chambers few, five or six in the last-formed whorl, periphery of each marked by clear material; sutures distinct, on the dorsal side somewhat oblique, ventrally nearly radial and more distinctly depressed; wall smooth; aperture at the margin of the last formed chamber, on the ventral side midway between the periphery and the umbilicus. Diameter 0,30 to 0,50 mm."

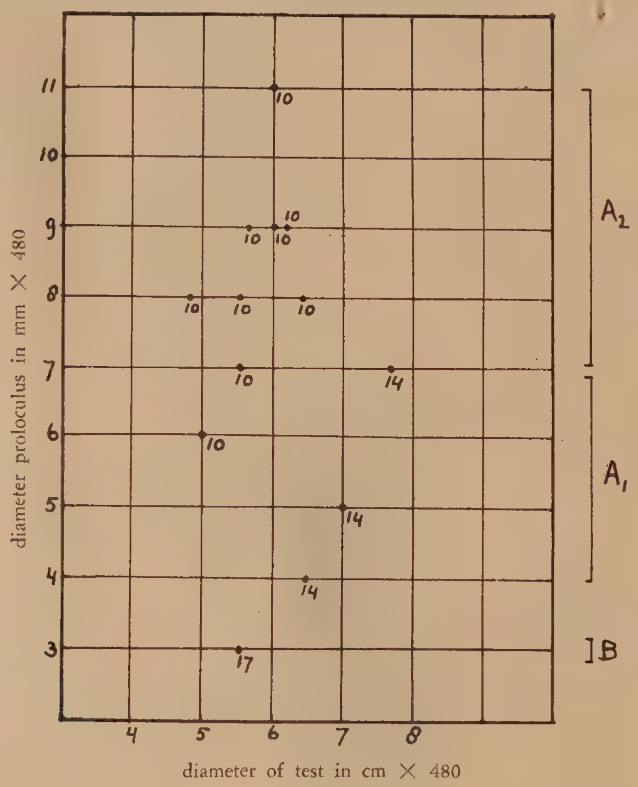


Fig. 219. *Pulvinulinella exigua.* Diagram showing relation between diameter of test and diameter of proloculus; the figures added indicate the number of chambers in the test. The three generations can be clearly distinguished by those numbers.

The species has been referred to by several authors from fairly deep water. It has been found in the Atlantic, as well as in the Pacific and Antarctic regions. This wide-spread distribution, together with the fact, that it is found in many typical *Globigerina*-oozes, points to a pelagic life; this is confirmed by the thinness of the test as well as by its inflated character.

It was Brotzen, who in his work "Die Foraminiferengattung *Gavinella* nov. gen. und die Systematik der *Rotaliiformes*" (Sver. Geol. Unders., Ser. C., No. 451, 1942, p. 38) pointed out, that *Eponides exigua* cannot belong to the genus *Eponides* as for its totally different aperture, while

Cushman created for those species the genus *Pulvinulinella,* which genus was interpreted by him (The Foraminifera, 1928, p. 292) as:

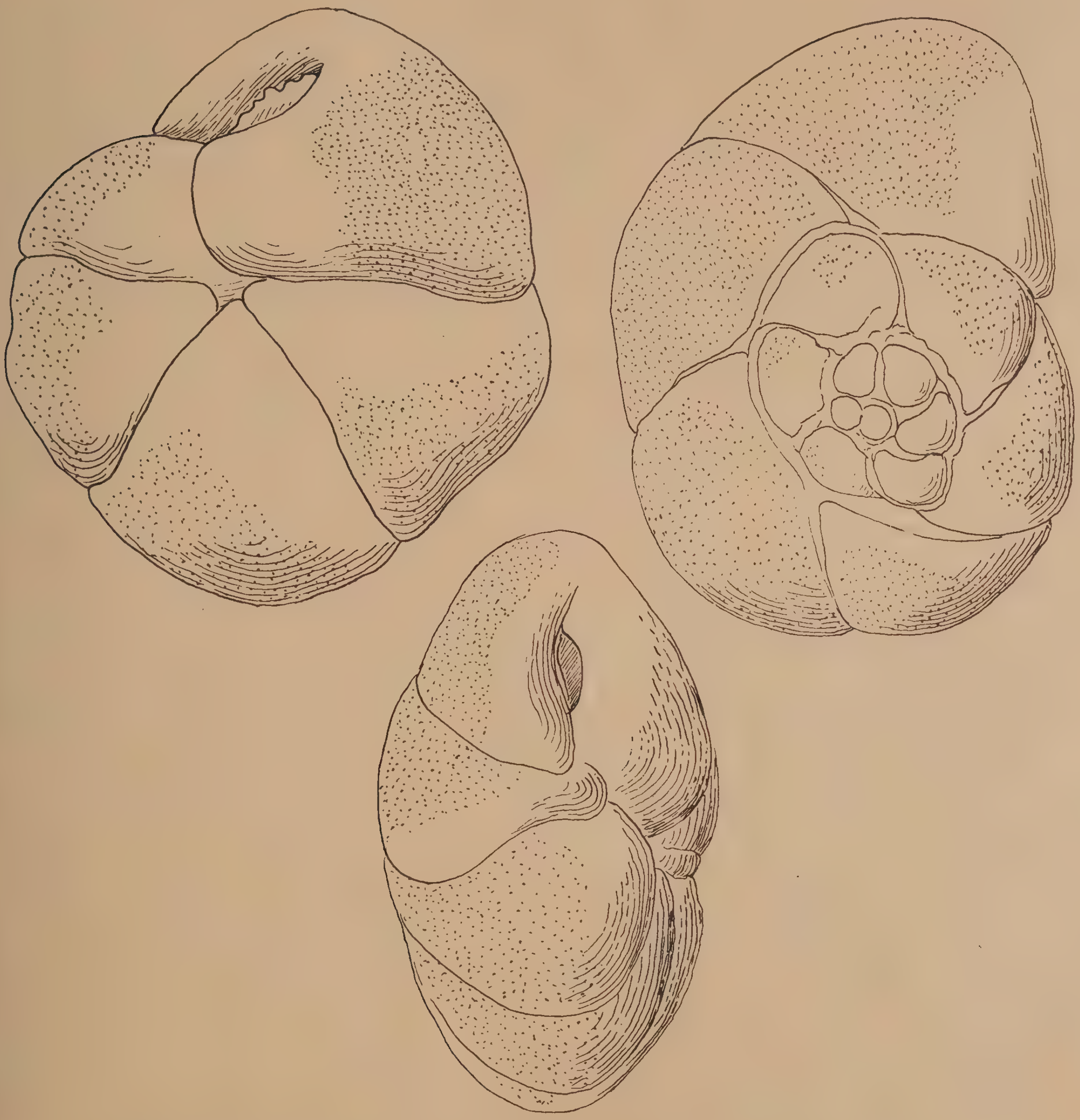


Fig. 220. *Pulvinulinella exigua.* Microspheric specimen, ventral and dorsal side and apertural face. × 600.

"Test trochod, close coiled, all chambers visible from the dorsal side, only those of the last-formed coil from the ventral side, very slightly if at all umbilicate; chambers numerous and distinct; sutures on the dorsal side oblique, on the ventral side nearly radial; wall calcareous, perforate; aperture on the ventral side of the peripheral face; elongate, somewhat loop-shaped, nearly parallel

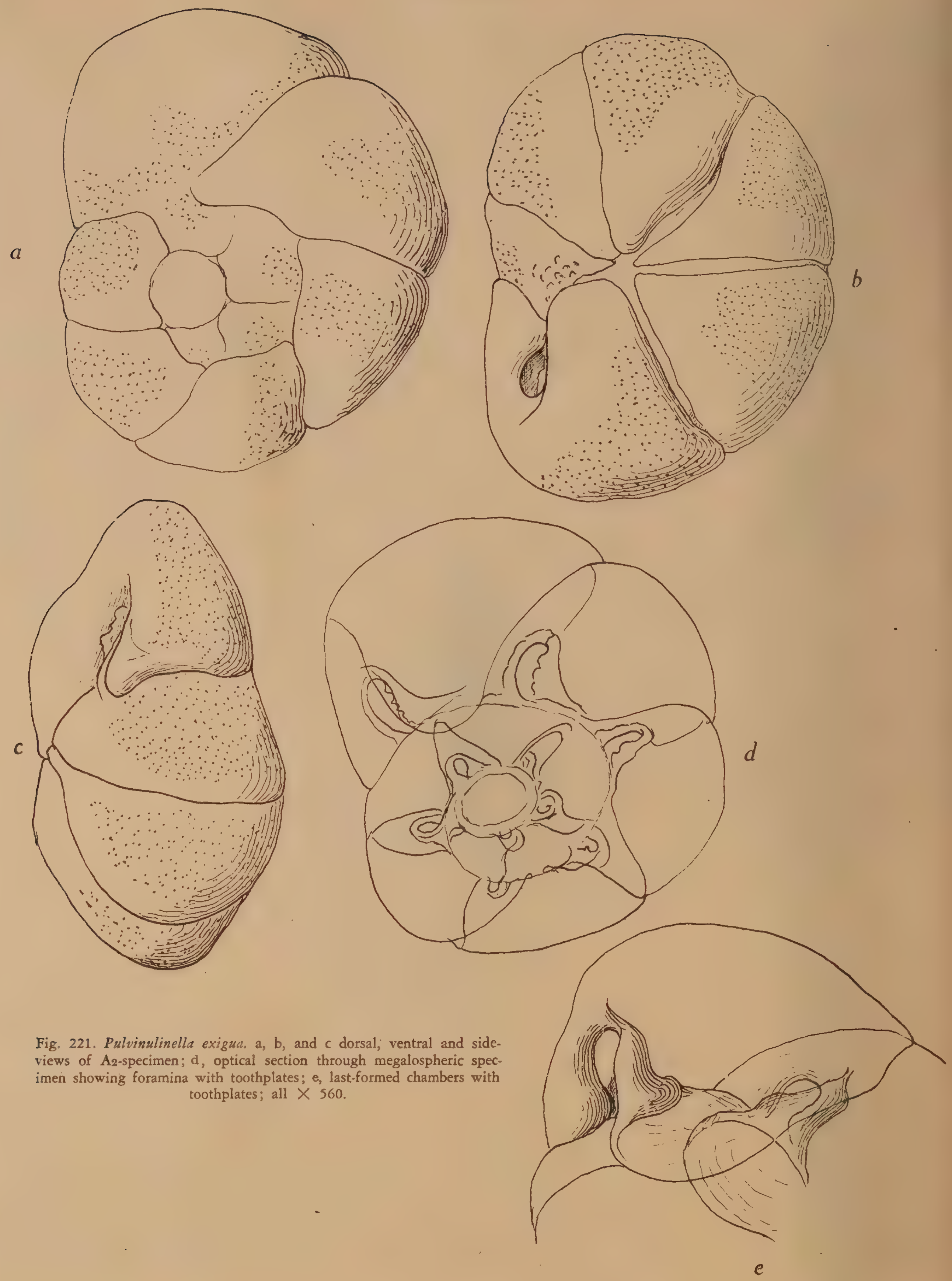


Fig. 221. *Pulvinulinella exigua.* a, b, and c dorsal, ventral and side-views of A2-specimen; d, optical section through megalospheric specimen showing foramina with toothplates; e, last-formed chambers with toothplates; all × 560.

to the plane of coiling, sometimes with a slight tooth-like projection of the margin on one side".

Why Cushman did not include *Eponides exigua* in his new genus *Pulvinulinella* in 1931, I do not know, but all characteristics, described by him in 1931 do fit for the genus *Pulvinulinella* from the year 1926, when Cushman first erected the new genus (Contr. Cushman Lab., Vol. 2, 1926, p. 62).

A loop-shaped aperture, together with a somewhat protruding tooth point always to dentate Foraminifera. Especially in the *Biforaminata* those apertures are fairly common. In most species of this group the toothplate is very well developed, whereas in *"Eponides" exigua* it has a very simple character. It consists here of an attached part, running in the way as it is found in *Cassidulina* or in *Cassidella,* along the inner chamberwall, then broadening and running upward along one of the borders of the aperture of the chamber, whereas the free folded part is reduced or has become the thickened other border of the loop-shaped aperture. As in *Ceratobulimina* or in *Lamarckina,* the aperture is totally obliquely built, and situated in an excavation of the apertural face of the last-formed chamber; this apertural face lacks the fine but distinct pores totally, together with the very fine pores, found on other parts of the test, along the sutures at the central parts of dorsal and ventral side. The attached part forms with the basal chamberwall a more or less distinct suture, as in *Ceratobulimina.* As in *Ceratobulimina,* the toothplates in the succeeding chambers are all arranged with their attached parts toward the dorsal border of the aperture; there is no alternation of them, as is found in *Cassidulina* or in *Bolivina.*

Moreover the walls of this species always are very lightly coloured yellowish, which is always the case in the *Biforaminata.*

All these characters point to that group, so that I believe Brotzen to be quite right, when he places the genus *Pulvinulinella* in his group of the *Ceratobuliminae.*

The species shows typical trimorphism too, as was stated statistically. The B-form with a proloculus of only 6 μ diameter, shows 17 chambers. The A_1-form, proloculus ranging from 8-12 μ, has 14 chambers, the A_2-generation with a proloculus ranging from 12-23 m, has invariably 10 chambers. In the last-formed coil the A-forms show 6 chambers, the B-forms too. There is only a very slight difference between A- and B-specimens; the B-form shows somewhat finer pores than the A-forms.

There is, however, another particularity in this species, on which I may call attention. This is the somewhat overlapping hyaline part of the wall at the foreside of the chamber on the ventral face. When studying this part, I found, that it begins at the ventral border of the aperture, where the attached part of the toothplate is found, and that its basal part directly derives from that plate; it runs first forward, forming the typical excavation of the apertural face, overlaps the former coil at the ventral side and then runs backward with a distinct hook to be connected with the ventral part of the wall which is pierced by the pores. This part, hence formed by a ventral outgrowth of the toothplate, totally lacks any trace of pores whatever.

This arrangement strongly resembles the overlapping plate, found over the umbilical region in *Lamarckina,* another Ceratobuliminine species, whereas on the other hand it resembles very much those typical poreless ventral plates, found in many so-called *"Discorbina"* as well as in *Baggina* and in *Cancris* and its related species and genera. But in *Cancris* and in *Discopulvinulina* there exists a second part, poreless too, running along the margin, whereas in *"Eponides" exigua* the marginal region is totally covered by pores. This poreless plate at the margin, found in real *Disco-*

pulvinulina and *Cancris,* and many other genera, derived likewise from an outgrowth of the toothplate, and can be traced easily in those forms, gathered into the genus *Globotruncana,* showing, that these genera are related to those forms, in which this marginal plate was more typically developed. This is one branch of Foraminifera, hitherto enclosed in the *"Rotaliformes",* which have derived from conorbide ancestors. Another line obviously shows no marginal development of the toothplate, and is related with those Ceratobuliminine groups, of which *Lamarckina* is an instance. They have developed especially the ventral outgrowth of the toothplate, and are characterised by a poreless ventral overlapping plate which, in species as this *"Eponides" exigua,* are attached to and finally totally have melted with the ventral normal wall of the chamber. But the porelessness of it clearly indicates its original homology with the ventral toothplate-part of *Lamarckina* and the apertural face of *Buliminella.* To this group must be brought such forms which are now known as *Pulvinulinella,* and moreover those Foraminifera included in the genus *Eponides.* In the latter genus the original toothplate itself is obliterated, but for a more or less distinct thickened border of the aperture, but it has remained in more or less development in a poreless part of the apertural and ventral wall of the chambers, ventrally to the aperture.

Genus **Eponides**

Real *Eponides* shows following generic characteristics:

Test in a more or less flat spiral, coiled. Chambers at dorsal side with oblique sutures, obliquely placed in respect to the margin; at ventral side sutures more radially placed, running up to the centre, no umbilical cavity. Aperture always narrow, a more or less elongate opening at the ventral part of the ventral suture, septal foramina always distinctly loop-shaped and areal, as is in reality also the aperture; pores always very fine; apertural face covered with pores, no trace of a closed protoforamen marginally of this face.

In regard to these characters, one has to consider the relation with other groups of Foraminifera.

The typical species of the genus *Gyroidina* often show the same narrow septal foramina; but the dorsal sutures in this genus are always radial, so that the shape of the chambers differs greatly.

The genus which may have been the ancestral genus of *Eponides* is *Pulvinulinella*; here the dorsal sutures are likewise oblique to the margin, and the ventral sutures reach toward the centre, as in *Eponides.* The apertures likewise show the loopshape; but here a very typical toothplate is present, showing that this aperture is a protoforamen, whereas that of *Eponides* may be a deuteroforamen. The genus *Alabamina* is not likely to have been the ancestor of the genus *Eponides,* though the dorsal sutures are always typically oblique to the margin, the ventral sutures are always radial, no umbilical cavity exists, but a loop-shaped deuteroforamen is present too, and in *Alabamina* the protoforamen has been closed and often nearly obliterated, together with the toothplate.

So it seems not likely, that *Alabamina* was the ancestor of *Eponides,* and so the genus *Eponides* must be removed from *Gyroidina.* The genus *Eponides* seems to have had no offsprings, and is the end of a long series of genera, *Lamarckina, Pulvinulinella, Eponides.* So I have placed the genus in the *Ceratobuliminidae,* though it shows not the typical characteristics of that family, the toothplate; this plate is totally reduced in this genus. But the fine pores are present yet, and the typical shape of the test suggests its close relation with *Pulvinulinella* without any doubt.

A remarkable difference between *Gyroidina* and *Eponides,* which at once makes clear, that these two genera are not so closely allied as has been supposed by authors, is found in the situation of the septal foramina. In *Gyroidina* these foramina are sutural, but in *Eponides* they are areal. This difference at once leads to the conclusion, that the septal foramina (and consequently the aperture, from which they derive) of *Gyroidina* are deuteroforamina, whereas those of *Eponides* are protoforamina. This coincides with the fact, that in *Gyroidina* the toothplate, when present, is found marginally from the foramen, whereas in *Eponides* the rests of it are seen doubtlessly axially to it. We shall prove, that *Gyroidina* shows the same situation of the septal foramen, found in *Alabamina,* and consequently it must have derived from or it is allied to that genus. On the other hand the genus *Eponides,* having a protoforamen without any indication of a deuteroforamen, may have derived from *Pulvinulinella.* Both genera show no trace whatever of an open umbilicus; they never possessed it; both genera moreover show very fine protopores, whereas the septal foramina are in both loop-shaped and situated in the middle-part of the ventral suture. These facts prove without doubt, that *Eponides* has moreover nothing to do with *Gyroidinoides* which, being an offspring of *Discopulvinulina,* shows a deuteroforamen with open umbilicus.

Eponides calida Cushman et Cole
(Figs. 222-224)

This species occurs fairly abundantly in samples from the Pliocene of the Netherlands. It is found as a Recent species in Arctic regions. I could study a very well preserved material provided kindly by the Geological Survey of the Netherlands. I mention it here, as it forms a very good example of real *Eponides,* and shows typical features.

Test coiled in a flat spiral, trochoid; dorsal side nearly flat or slightly convex in the microspheric form, chambers more inflated on the ventral side. At dorsal side surface smooth and even shining, with slightly limbate sutures which are quite distinct. The chambers with slightly rounded sutures obliquely backward in respect to the margin. Pores extremely fine, all over the dorsal side. At ventral side sutures slightly rounded and nearly radial. Here however they are covered by a development of fine but very distinct pustules, which cover the whole umbilical area and the larger part of the sutures which are only free near to the margin. The aperture is very narrow, rounded, but typically loop-shaped from the inner side, at the outer side of the wall nearly totally covered by the pustules. The loop-shaped narrow septal foramina are typically areal. In the microspheric form they may be enlarged secondarily and then become interio-marginal.

Two specimens found had a diameter of proloculus of 6 and 10 μ, followed by resp. 18 and 16 chambers; they are the microspheric generation. Most of the individuals showed a proloculus measuring from 18-40 μ; they form the megalospheric generation; their number of chambers ranged from 10 to 16, most of them 12 chambers. Two distinct groups of A-forms could not be traced.

The number of chambers in the last-formed whorl ranged from 5 to 8, mostly 6 or 7. There seems to be no difference in that number in both generations. In transverse section the megalospheric form shows the roofs on the dorsal side of the chambers nearly in a flat plane, whereas the roof of the chambers in the microspheric form is much more convex.

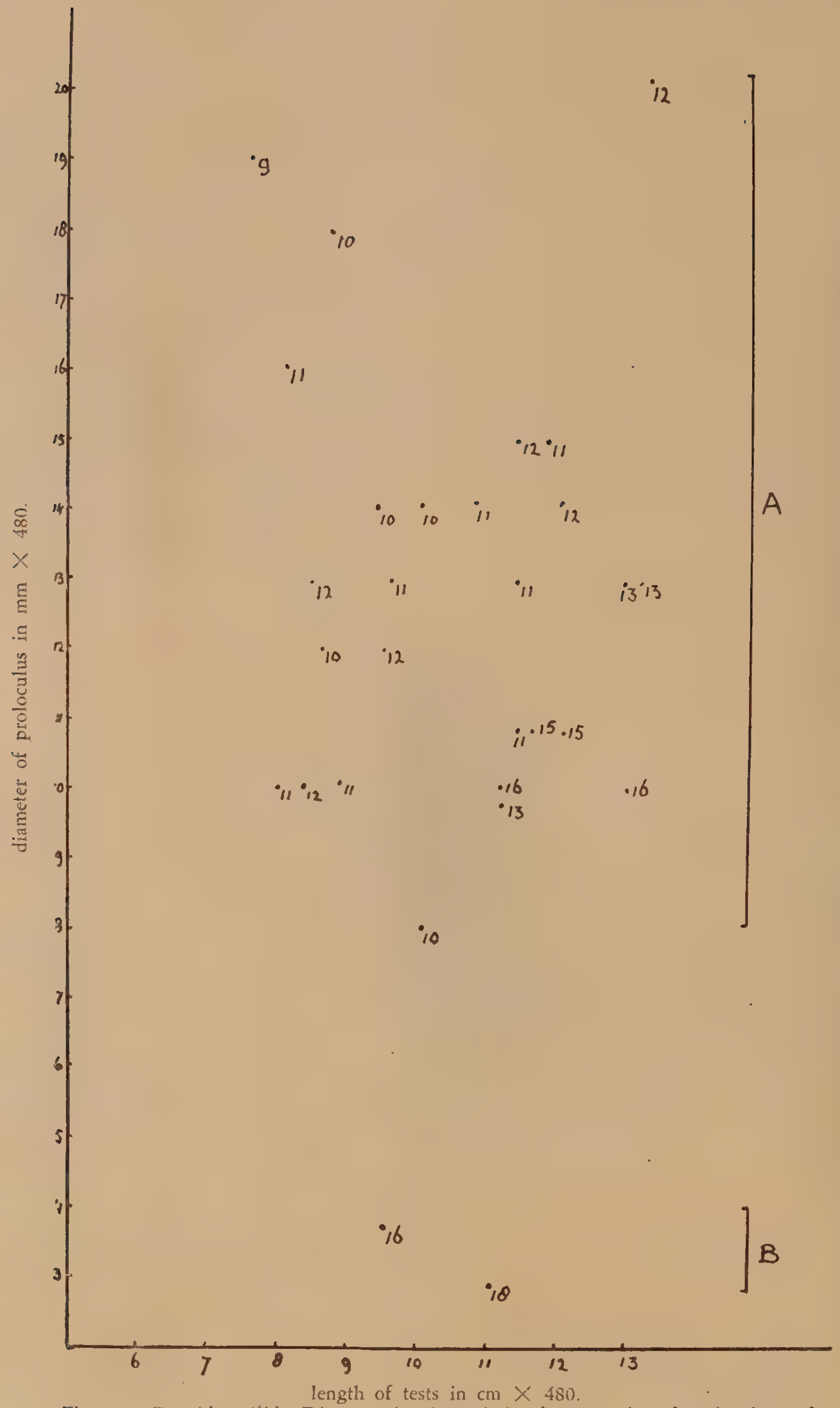


Fig. 222. *Eponides calida.* Diagram showing relation between size of proloculus and size of test; figures added indicate number of chambers. The A-generation cannot be divided into two sets, and so propagation seems to be of the dimorphic type.

Diameter of species ranging from 0,15 to 0,27 mm, thickness of test from 0,9 to 0,12 mm. The walls are, especially at the dorsal sides, rather thick, but also fairly translucent.

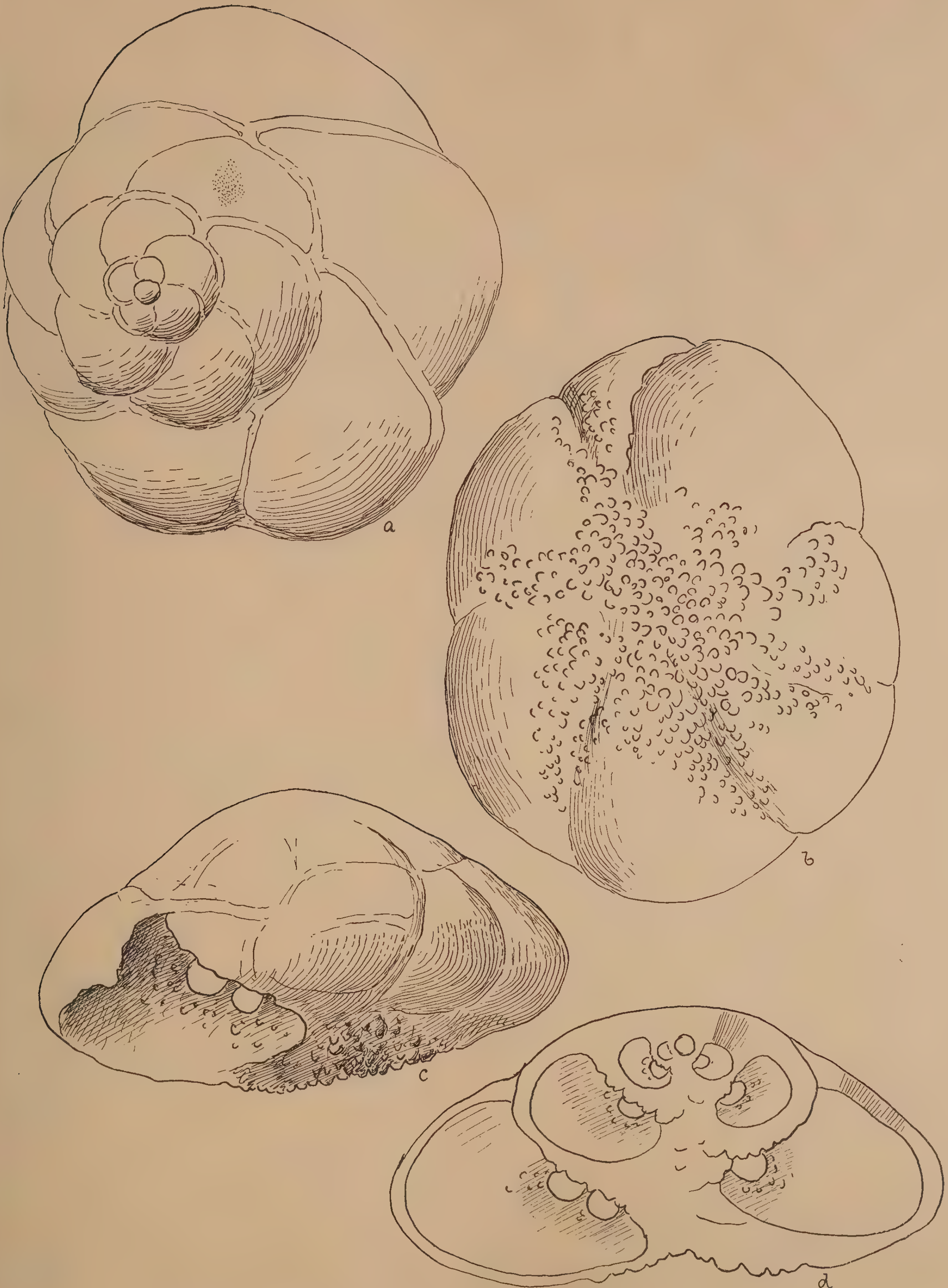


Fig. 223. *Eponides calida.* a, b, c, three views of microspheric specimen; d, transverse section. × 480.

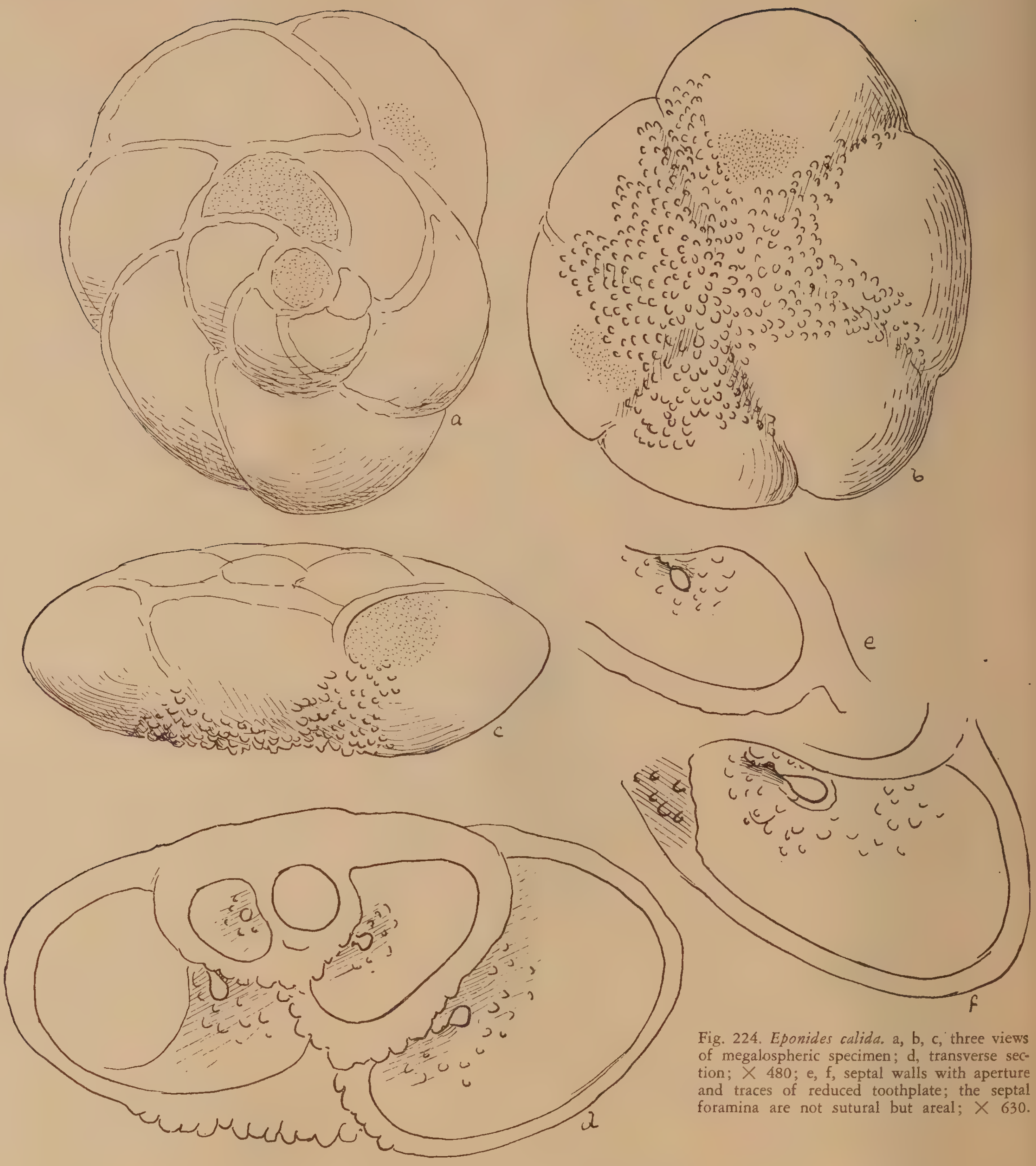


Fig. 224. *Eponides calida.* a, b, c, three views of megalospheric specimen; d, transverse section; × 480; e, f, septal walls with aperture and traces of reduced toothplate; the septal foramina are not sutural but areal; × 630.

Eponides repanda (Fichtel et Moll)

(Figs. 225, 226)

In several gatherings in the Archipelago, especially south of Sumatra, some specimens occurred, which I thought best to call *Eponides repanda.* They occurred abundantly in a gathering, which I got from Huasco, coast of Chile.

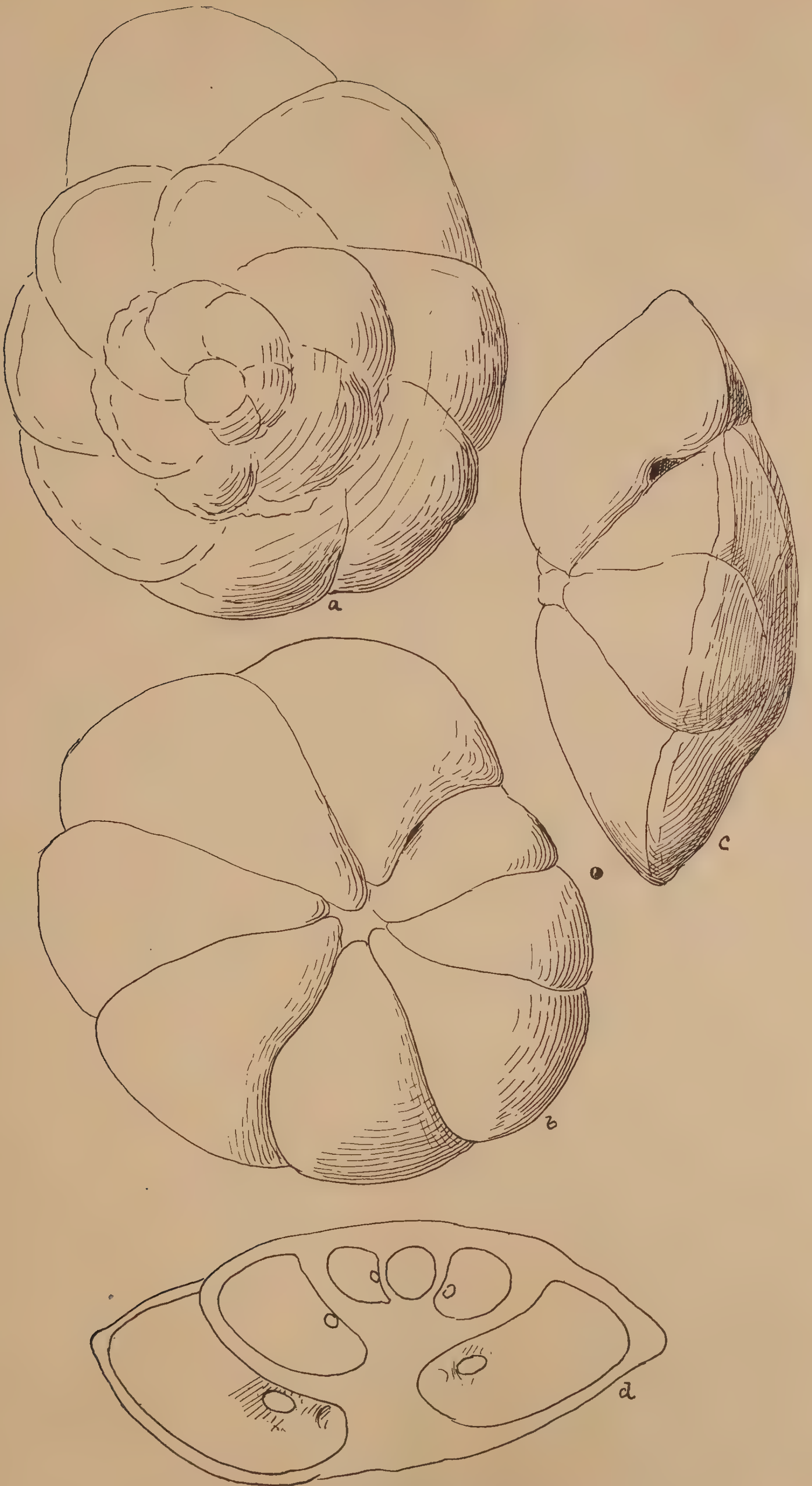


Fig. 225. *Eponides repanda.* a, b, c, three views of megalospheric test; d, transverse section; × 480.

Test always opaque and white, when dry. Pores all over the surface, very fine. Periphery more or less acute, with more hyaline edge; dorsal and ventral sides convex. At dorsal side sutures distinct, especially in the last-formed coil, slightly curved, obliquely directed backward. Chambers numerous, total number up to 22, in the last-formed whorl from 7 to 10. At the ventral side sutures less distinct, nearly radiate, leaving only a narrow umbilicus free, which is filled-up with chalk material. Aperture an indistinct very small opening in the umbilical part of the ventral suture. In sections the septal foramina are very small, rounded or slightly elongate. Length from 0,20 to 0,40 mm.

The species shows the typical character of real *Eponides,* with its very small foramina. Traces of the toothplate were found in some sections as an indistinct pillar-shaped building ventrally to the septal foramen. This situation coincides with that of the *Conorbida* and not with that of *Alabamina;* but the reduction of it was too large, to give clear conclusions about its real place.

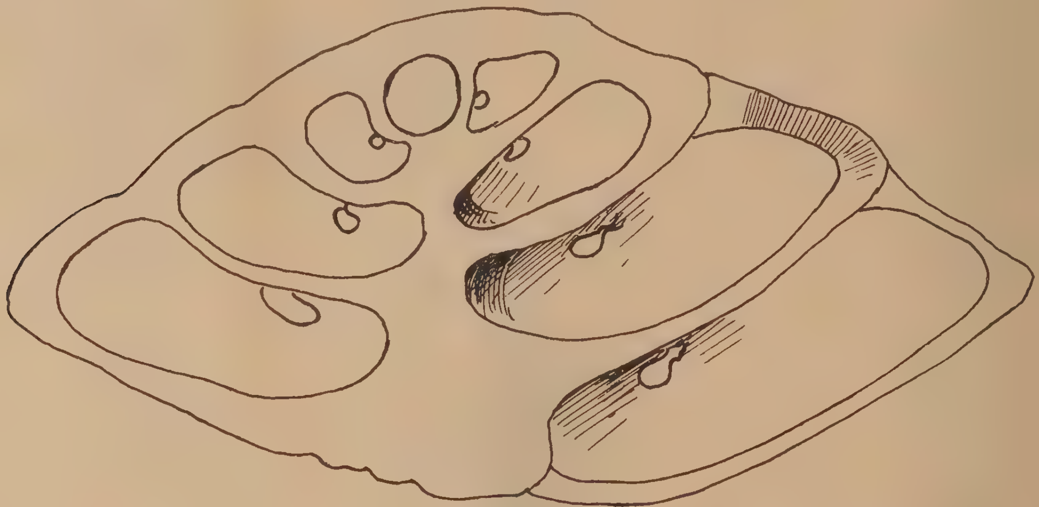


Fig. 226. *Eponides repanda.* Transverse section through large specimen, with the septal foramina. × 480.

All specimens found were megalospheric.

Family *Cibicidae.*

This family includes the genera *Parrella, Siphoninella, Siphonina* and *Cibicides.*

In *Parrella* the aperture is a protoforamen, whereas in fossil species a deuteroforamen may develop. But, as here the protoforamen in all cases is maintained, whereas the deuteroforamen is more and more reduced, I have placed the family in the protoforaminata among the *Biforaminata.* But the development of a deuteroforamen in fossil species (*Parrella lens*) may point to the derivation from biforaminata.

While in several genera of *Parrella* a toothplate in relics is found, in the other genera this plate is totally obliterated. Yet the place of the protoforamen, always near to the margin, indicates their relationship with *Parrella,* as has already been stated by Brotzen.

Parrella shows protopores in the walls, but in *Parrella culter* an indication of the forming of deuteropores is already given. In the allied genera *Cibicides, Siphonina* and *Siphoninella* deuteropores have become a rule. All these genera show marginal foramina, and totally closed umbilici, though in some species of *Cibicides*, known as *Anomalina,* this umbilicus secundarily is opened, as the chambers do not reach the centre. But then the chambers also are overlapping at the dorsal side, at least those of the later whorls.

Parrella is a typical Cretaceous and Tertiary genus, though there are some representatives in recent oceans also. In the Cretaceous the genus *Cibicides* seems to develop too; older records have to be restudied.

There is much controverse as to the ventral and dorsal sides of the genus *Cibicides.* In *Parrella* the ventral side is the one, at which the chambers are overlapping, reaching the centre. In many species of *Cibicides,* and in *Siphonina* this is likewise the case. In *Parrella culter* only at the dorsal side deuteropores are found; in many species of *Cibicides* this is likewise the case. In the case that in *Cibicides* the aperture forms a slit along the spiral suture at one of the sides, its main part is found at the margin. This side with the slit on the spiral suture is the dorsal one, as is revealed by sections. So, many species are attached with their dorsal sides to a substratum, e.g. *C. refulgens. Cibicides* has in such way nothing to do with *Gavelinella,* as Brotzen believes.

Siphoninella and *Siphonina* have developed in the Tertiary.

Genus **Parrella**

This genus has found an exhaustive treatment in Brotzen's new work (Sver. Geol. Unders., Ser. C., No. 93, 1948, p. 103-106). Till now only a single species was known from recent seas. I have found in the material from the Malay Archipelago a second species, *Parrella venusta* (Brady). It shows a striking character in its aperture which shows the two parts, found in fossil species, but now united in a single aperture, whereas *Parrella culter* has a simple aperture, obviously the result of further uniting of both parts. In *P. venusta,* as well as in *P. culter* I could state, that the toothplate, though reduced, is still present, and runs from the septal foramen along the axial wall toward the marginal side of the next one, and the lip, deviding the two parts of the aperture, especially in *P. venusta,* is the toothplate of the next chamber, already built up. So it is obvious, that the marginal aperture is a protoforamen, as the marginal aperture in *Epistomina.*

Both recent species show a typical keel at the margin, which, united with the poreless part of the apertural face, strongly suggests its being formed by the toothplate, as in *Laticarinina.*

The genus was traced down to the Upper-Cretaceous.

Parrella venusta (Brady)
(Figs. 227, 228)

This species was found in abundance in the gathering off Merak, Strait Sunda, depth about 10 fathoms, anchorage.

Only megalospheric specimens were found, the proloculus measuring 30-80 μ.

Test biconvex, composed of 1½ to 2 whorls of rather inflated chambers, with a distinct granulose keel at the margin. At dorsal side all chambers visible, with distinct depressed septal sutures, slightly oblique to the margin, and raised, granulose spiral sutures, as is found in many species of *Globotruncana* and allied genera. At dorsal side chambers slightly inflated, much more on ventral side in the flat trochoid spiral. At ventral side only the chambers of the last-formed whorl visible, with distinct depressed sutures between, leaving free a rather large umbilicus which is filled up with irregular secondary chalk buds. At ventral side the poreless granulose keel is distinct, even more as is the case on dorsal side. At dorsal and ventral side, especially at the ventral one, irregular thickenings of the walls are found, at which the fine pores are lacking; this reminds of the irregular poreless wallparts of *Epistomina elegans.* Diameter of test up to 0,7 mm, thickness up to 0,28 mm. This species may have been described under the name of *Eponides fijiana* Cushman 1933, Lab. Foram. Res., vol. 9, pt. 4, p. 89, pl. 9, figs. 6 a-c, for often the chambers show the typical points at the middle of the margin. But Cushman's description and figures are not detailed enough to have any certainty.

The aperture is near the ventral suture of the last-formed chamber, slightly areal, and heavily curved by a typical lip, partly closing the aperture. In this way this aperture is somewhat half-moon shaped, but, contrary to those, found in many other species of Foraminifera, not with the crescents toward the suture, but toward the margin. This leads to the suggestion, that the aperture is a protoforamen, with the toothplate attached to the marginal part of it, and the areal situation underlines this suggestion.

This suggestion is moreover ascertained, when sections are studied. Horizontal sections showed to me, that the aperture is connected with the former one by means of a rather reduced, but distinct toothplate, quite hyaline, running along the basal wall of the chamber. It begins at the lip or tooth of the former aperture, now septal foramen, and ends at the ventral side of the next aperture. At the opposite side of that aperture is formed the rather protruding lip, the beginning thus of the next toothplate. In some chambers this toothplate is somewhat better developed, and shows a distinct, though reduced, free folded part.

These characters all point to the *Ceratobuliminidae.* The clear, very slightly opaque walls, the somewhat larger pores, though typical protopores, the remarkable keel, and the whole shape of the test point in the direction of the *Marginolamellidae.* This is underlined by the fact, that the apertural face largely is lacking pores, only a few conspicuous knobs of chalk are visible here, and this clear poreless face is continued in the poreless keel. This is likewise a character of the *Marginolamellidae.*

In *Parrella culter* the keel, the shape of the aperture, even the large umbilicus which is found in many specimens, likewise indicate the relationship with the species, now studied here. The reduced toothplate of *Parrella culter* strongly resembles that of the species described here. I am convinced, that the species belongs to the genus *Parrella,* so that two recent species of this genus are now known.

The aperture of *Parrella* has been carefully studied in the species *Parrella lens* by Brotzen (Sver. Geol. Unders., Ser. C., o. 465, p. 56) and it was shown, that this aperture is a single one, devided into two, often quite separate parts, by a large lip; here likewise the crescents of the moon, formed by the whole aperture, are directed toward the margin. So, at least the more dorsally situated part of the aperture is the one, comparable with the marginal protoforamen of *Epistomina,* and Brotzen does not hesitate to homologize them (Brotzen, 1948, Sver. Geol. Unders., Ser. C., No. 493, p. 104-105). But, whereas in fossil *Parrella* the two openings never fuse, in *Parrella venusta* they do, and in *P. culter* this process is continued, so that in that species a single opening results.

In this way the part of the apertural face between the two foramina, is mainly formed by the toothplate itself.

The number of chambers of the last-formed coil of *Parrella venusta* is 7 or 8.

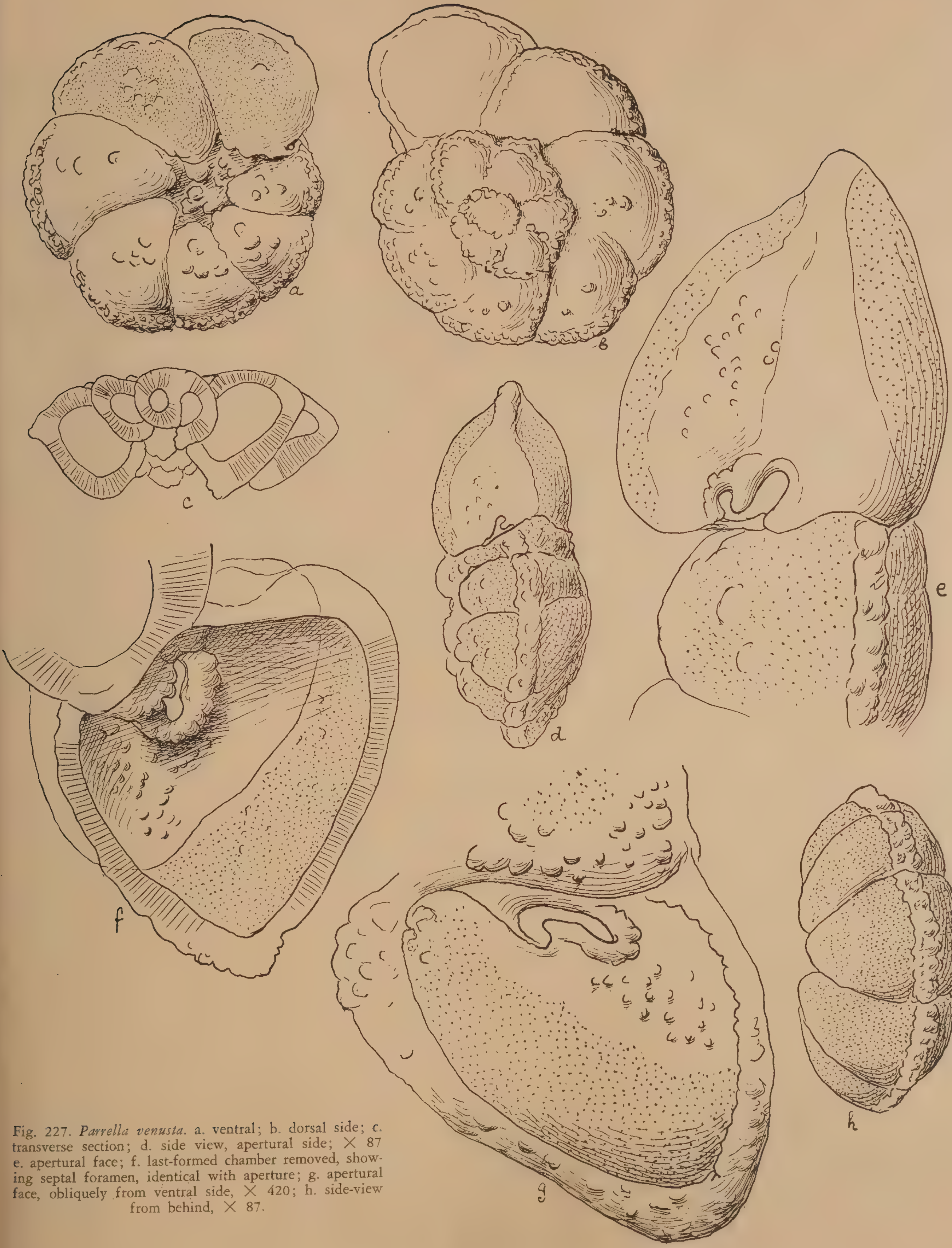


Fig. 227. *Parrella venusta.* a. ventral; b. dorsal side; c. transverse section; d. side view, apertural side; × 87 e. apertural face; f. last-formed chamber removed, showing septal foramen, identical with aperture; g. apertural face, obliquely from ventral side, × 420; h. side-view from behind, × 87.

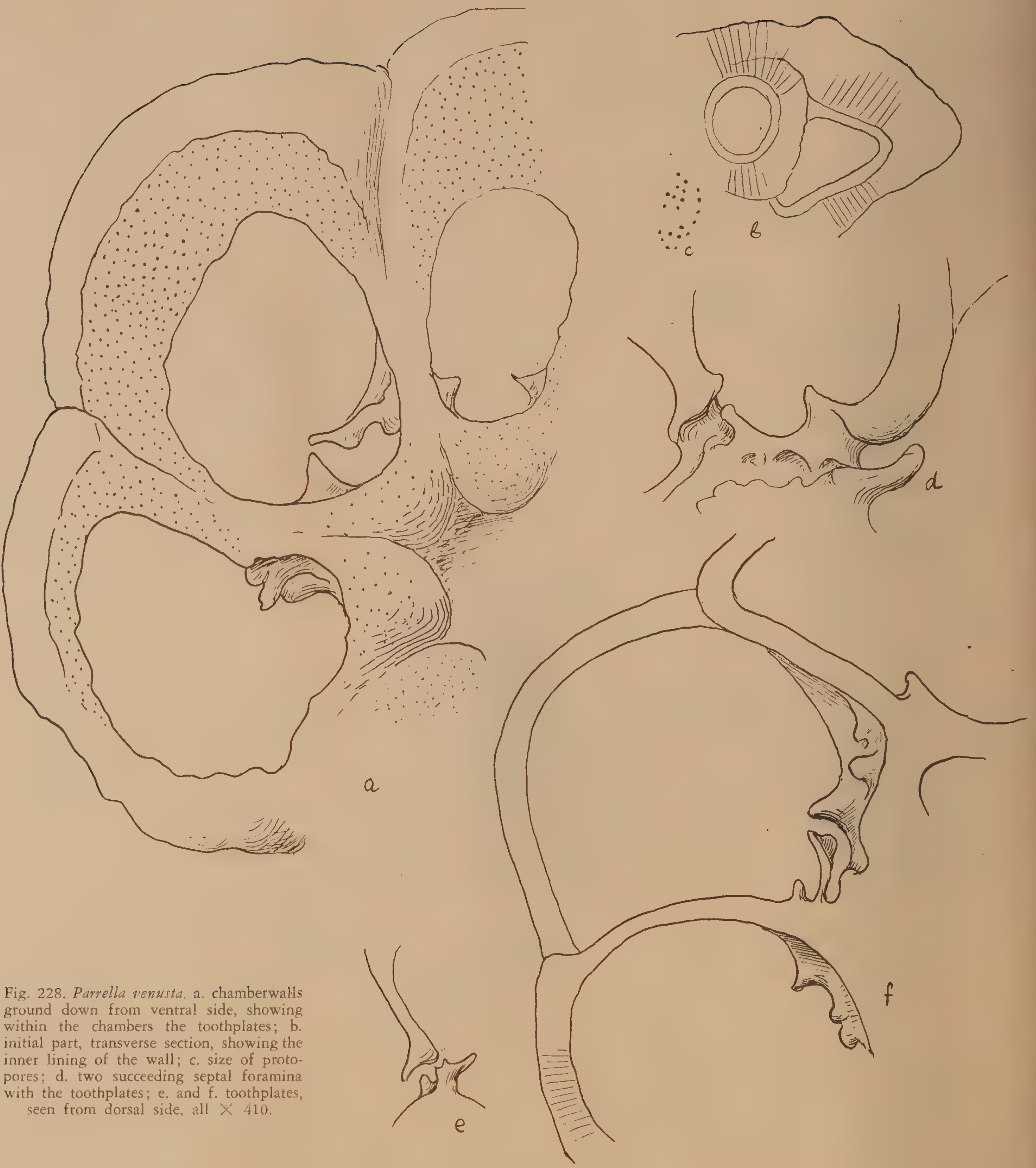


Fig. 228. *Parrella venusta.* a. chamberwalls ground down from ventral side, showing within the chambers the toothplates; b. initial part, transverse section, showing the inner lining of the wall; c. size of protopores; d. two succeeding septal foramina with the toothplates; e. and f. toothplates, seen from dorsal side, all × 410.

Parrella culter (Parker et Jones)
(Figs. 229-232)

This species is always rare in the samples. It occurred at St. 1° 51′ S., 99° 36′ E., depth 683 fathoms, and St. 1° 35′ S., 99° 52′ E., depth 977 fathoms, so always in considerable depths. In some abundance it was met with at St. 2° 58′ S., 99° 47′ E., depth 928 fathoms.

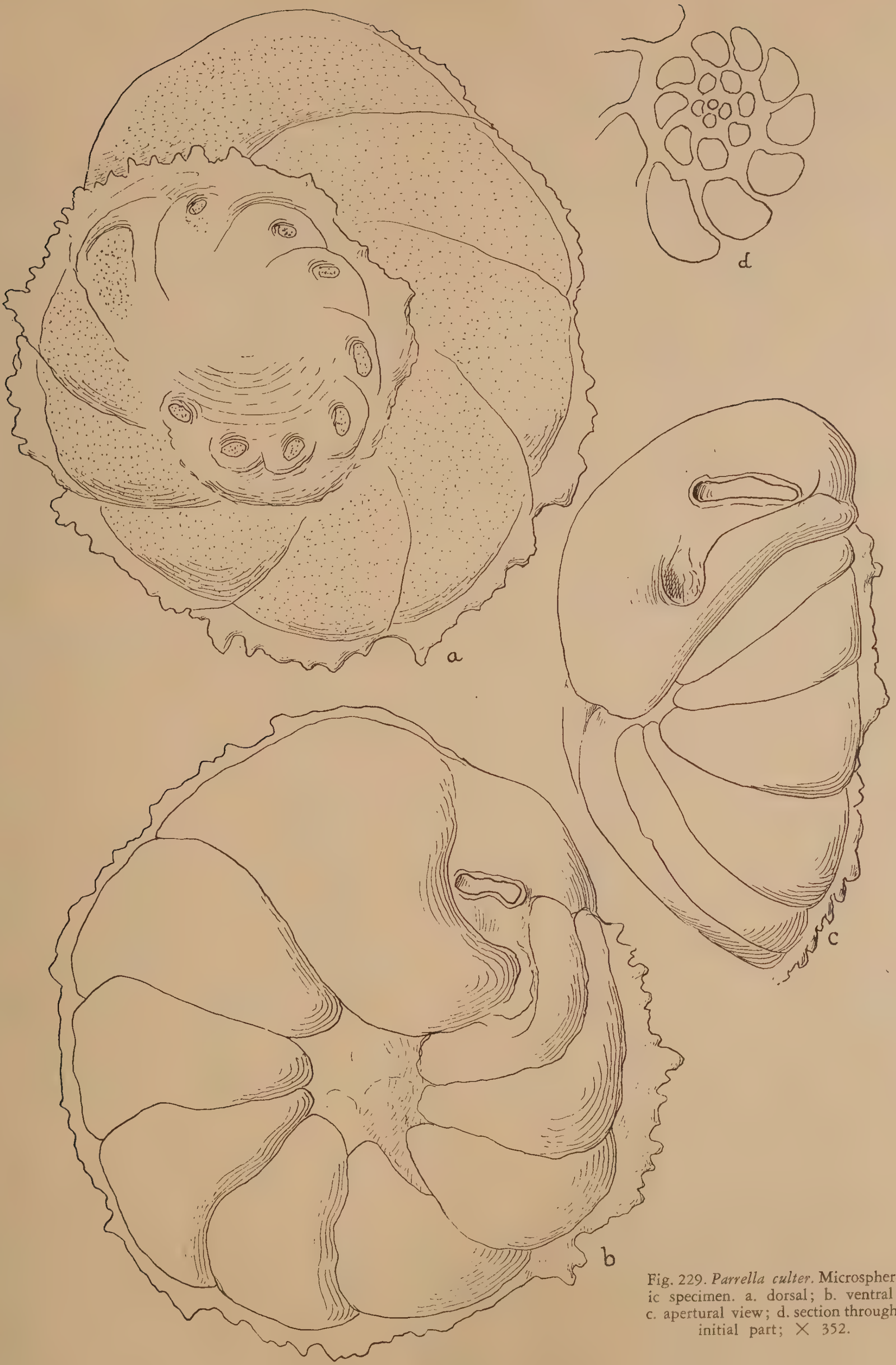


Fig. 229. *Parrella culter.* Microspheric specimen. a. dorsal; b. ventral; c. apertural view; d. section through initial part; × 352.

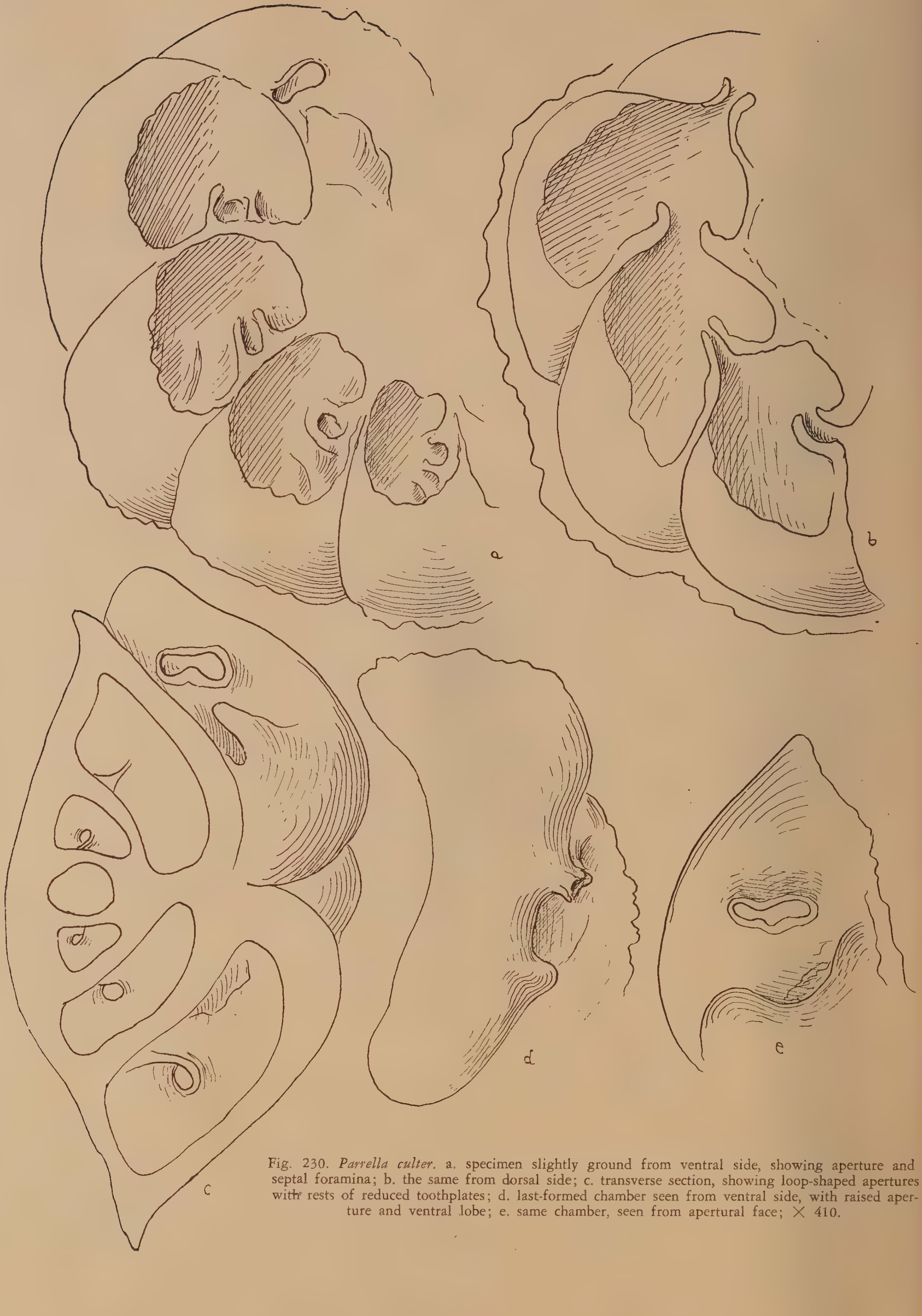


Fig. 230. *Parrella culter.* a. specimen slightly ground from ventral side, showing aperture and septal foramina; b. the same from dorsal side; c. transverse section, showing loop-shaped apertures with rests of reduced toothplates; d. last-formed chamber seen from ventral side, with raised aperture and ventral lobe; e. same chamber, seen from apertural face; × 410.

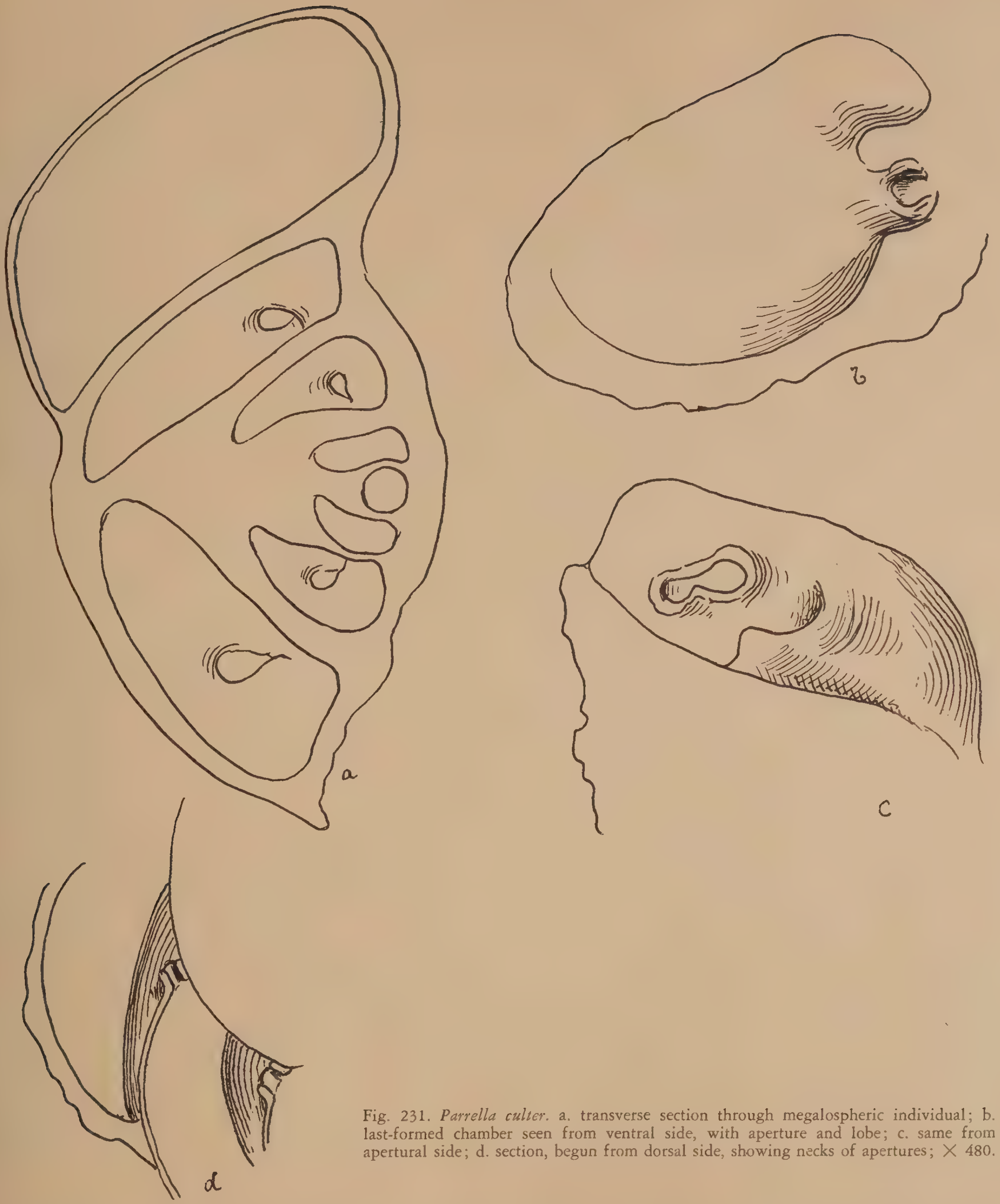


Fig. 231. *Parrella culter.* a. transverse section through megalospheric individual; b. last-formed chamber seen from ventral side, with aperture and lobe; c. same from apertural side; d. section, begun from dorsal side, showing necks of apertures; × 480.

The dorsal side is slightly convex, with a somewhat upraised outer border which always shows a fringed keel. This keel is always more hyaline than the opaque wall of the test, and is lacking any trace of pores; thus it forms the border between the porous dorsal and the poreless ventral sides. No relation exists between this keel and the aperture. The ventral side is always highly convex, with inflated chambers and somewhat depressed sutures. In the microspheric form a relatively large umbilicus is found, filled however with chalk, whereas in the megalospheric forms

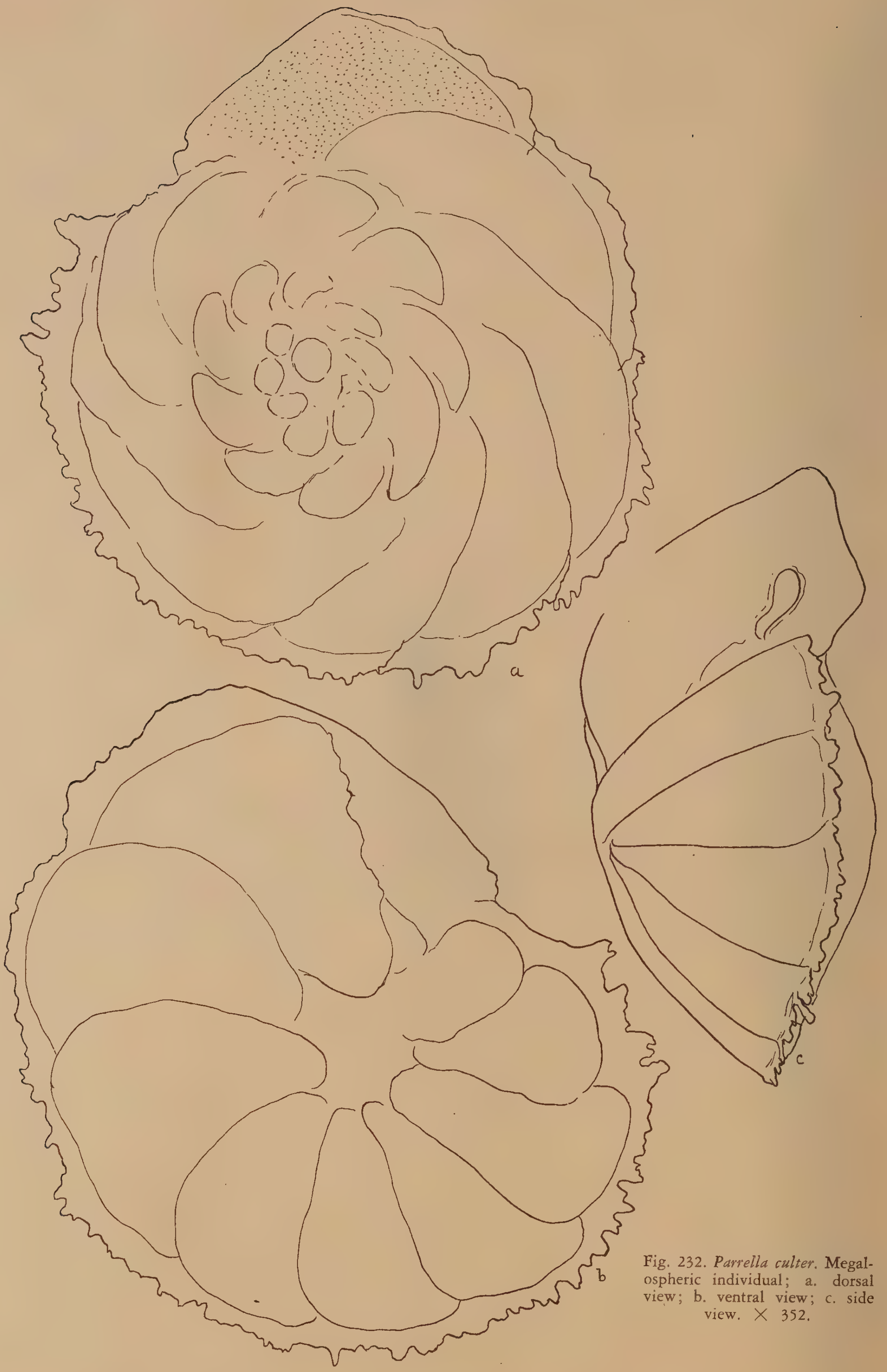


Fig. 232. *Parrella culter.* Megalospheric individual; a. dorsal view; b. ventral view; c. side view. × 352.

the chambers of the last-formed whorl meet at the umbilical region, so that only an indistinct umbilical area is left.

The sutures at the ventral side are nearly radial, with the part at the margin running backward; the sutures at the dorsal side are slightly curved and strongly directed backward, especially in megalospheric specimens. In younger tests the apertural face shows a single aperture, with a protruding neck, nearly rounded and loop-shaped; in older individuals the aperture, forming an angle of about 45° with the ventral suture, is elongate and often devided into two connecting parts by a tongue at the ventral border. Ventrally from this aperture is a bulky part of the chamberwall, which may be looked at as a second aperture; but a real opening in it never could be traced. A very much reduced toothplate, or only the base of it, runs from the aperture along the basal part of each septum, thus indicating the real nature of the species. This reduced toothplate at one hand, and the neck at the aperture at the other, show, that this species has to do with *Pulvinulinella* and with *Siphonina.* We may thus consider the genus *Parrella* as a link between *Pulvinulinella* and *Siphonina.* The pores are rather fine and restricted to the dorsal side only. The ventral side, with its opaque structure, shows only very fine granulations which suggest a fine aglutination, as is found in many *Cibicides* species as well. The walls are of the opaque type, with fine granulations in it. In older tests a thick layer of secundary chalk is covering the central dorsal side, and, especially in the microspheric form round spots above each chamber are spared out to give the pores a possibility to attain the surface. The size of a test of this species is in diameter up to 0,35 mm.

The relation of this *"Truncatulina" culter* with the genus *Parrella* was first mentioned by Brotzen. It would be very interesting to learn, if fossil *Parrella* show better preserved toothplates as it is the case in this recent species. The species is found mainly in Globigerine ooze.

Genus **Cibicides**

This genus has been analysed with its related genera especially by Brotzen (Sver. Geol. Unders., Ser. C., No. 451, 1942). He lets this genus, together with *Stensioina, Cibicidoides, Anomalinoides, Planulina, Anomalina* derive from *Valvulinerid* forefathers. To this standpoint I have to object with the following arguments:

1. In *Valvulineria* the aperture shows the characteristics of the deuteroforamen of *Discopulvinulina,* and thus has to be looked upon as a descendant of the *Conorbida.* It is a *Discopulvinulina,* in which the protoforamen with its toothplate has been totally reduced. In *Cibicides* and related genera the aperture shows all characteristics of a protoforamen, in which the toothplate has been obliterated, and can be easily derived from *Parrella.* It is a *Parrella,* in which the aperture has been somewhat simplified, and the lip of the aperture is not identical or homologous with the lip on the aperture of *Discopulvinulina.* For in *Discopulvinulina* the lip is situated axially from the aperture, whereas in *Cibicides* this lip is situated marginally from the aperture. This difference is of high importance, as the situation of this lip decides between the protoforaminal or deuteroforaminal nature of the aperture. For, when we consider closely the apertures of the *Conorbidae,* related with *Discopulvinulina,* we find, that the apertural lips are always situated axially from the deuteroforamen, and marginally from the protoforamen. Even in those forms, now named *Neoconorbina* (See my work on West Indian Foraminifera) we can easily prove, that the protoforamen is situated proximally, and the deuteroforamen distally to the apertural lip.

In *Valvulineria* and *Gavelinella,* the lip is always situated axially to the aperture; and often opens into the umbilical space, as is the case in *Neoconorbina* and *Discopulvinulina.* But in the genera, allied to *Cibicides,* this lip is always situated marginally from the aperture, and never opens into the umbilical cavity. So the lips of these two groups are quite differently situated, and in this way their apertures are not homologous. In the recent species of *Parrella, P. culter, P. venusta* and *P. rosea,* I could state, that often a small but distinct lip is found about the aperture; this lip surrounds the aperture more or less. So it has much more features in common with the lip of *Cibicides,* than of *Discopulvinulina.* But there are other characteristics, which point directly to *Parrella,* and not to *Discopulvinulina* and the *Valvulineridae.*

2. In *Valvulineria,* and in *Gavelinella* and *Gyroidinoides,* the dorsal side of the chamberwalls is always covered with fine protopores (*Valvulineria*) or without any pores (*Gavelinella* and *Gyroidinoides*). In *Cibicides* on the other hand always deuteropores occur, and these are mainly situated on the dorsal side, whereas in many species the venrtal side lacks pores throughout. In the species of *Parrella,* the dorsal side is covered with protopores, whereas the ventral side is lacking pores in *P. culter* and *P. lens,* and is partly covered with protopores in *P. venusta.* In *P. culter* the older parts of the dorsal test are covered by layers of secondary chalk, leaving free small areas for the protopores, thus indicating the forming of typical deuteropores. In *P. rosea* these pores have been transformed already totally into deuteropores, but here pores are mostly lacking on the ventral side of the test. In *Cibicides* and its allied genera, the pores always are deuteropores, and often, as already has been mentioned, are lacking at the ventral side of the test.

3. The structure of the wall of *Valvulineria* and *Gavelinella* is that of a hyaline wall, in which protopores are found. There are no species known, in which the walls are of an opaque structure; in some species of *Gavelinopsis* the walls of the older coils show a brownish colour, but this colour is due to a secundary lining of brown material at the inner side of it. In the genera, allied to *Cibicides,* the walls are often of an opaque structure, often throughout yellowish or brownish in section, and lack the protopores, typical for hyaline walls.

I have to point out here, that some species, hitherto called *Cibicides* with hyaline walls and protopores, have proved to belong to quite different genera, such as *Discopulvinulina.*

All these facts together give little doubt as to the systematic place of the genera, allied to *Cibicides.* They are without doubt descendants of *Parrella,* and thus have to be placed among the *Ceratobuliminidae,* and their apertures derive from protoforamina.

The genera *Valvulineria, Gavelinella, Gyroidinoides* and *Gavelinopsis* have derived from ancestors which must be allied to *Discopulvinulina,* and have nothing whatever to do with the *Cibicidae,* as they have to be placed among the *Conorbidae.*

In the *Cibicidae,* the apertural conditions may be generalized as follows:

The aperture is a more or less suturally placed slit at the ventral suture, often in the middle of it, and more often above the middle, even creeping up toward the marginal region. It is provided with a more or less thickened border or lip, as in *Parrella.* Often it shows an apertural lip which is situated always more marginally than axially to the opening, and often is extending upwardly toward the marginal part of the test. In some cases this lip creeps up dorsally from the margin, and in that case forms an aperture which is even opening at the dorsal spiral suture of the test. Never the lip of the aperture is situated ventrally from it, and consequently the aperture never opens into the umbilical cavity. The aperture is typically protoforaminal.

In the *Valvulineridae* on the other hand the apertural conditions may be described as follows: The aperture is a more or less suturally placed slit at the ventral suture, often in the middle of it, and more often below the middle, even creeping down toward the umbilical part of the suture. It is provided with a more or less developed lip, as in *Discopulvinulina,* which is always situated ventrally from the opening, and often forms in this way an open slit, continuing from the main aperture and opening into the umbilical cavity. In some cases this lip covers part of the umbilicus itself. So in these forms the aperture often opens into the umbilical cavity, but it never shows any indication of a marginal or even dorsal opening of the aperture. The aperture is typically deuteroforaminal.

After having cleared these points, we shall now consider the different genera of the *Cibicidae.* They have been described by Brotzen in the following way:

Cibicidoides Brotzen.

Test equally convex on both sides; spiral side often involute, the older whorls involved by the latest one conically. Umbilicus filled up or lacking. Aperture interomarginal septal, umbilical opening in the spiral suture. Type: *C. eriksdalensis* Brotzen.

We do not know, if in reality the side, described by Brotzen, in which the aperture opens suturally, is the ventral one; only transverse sections will disclose this question. But if this side is the ventral one, and if in reality the chambers are involute on the dorsal side, the species *C. eriksdalensis* seems to be related with some *Discopulvinulina,* and not with *Cibicides.* In many species of *Discopulvinulina* the chambers at the dorsal side are overlapping. I proved this for the species *D. pseudolobatula, D. hyalina* from the Pacific, whereas the species *D. subaraucana* and *D. bertheloti* from the East-Indian region show a partial overlapping of the dorsal side. There are, on the other hand, many species of *Discopulvinulina,* which show no traces of overlapping or only a slight overlapping of the dorsal side. So we cannot consider the overlapping on the dorsal side as a typical generic characteristic, and consequently the genus *Cibicidoides,* in case that its species are proved to belong to the genus *Discopulvinulina,* has to be dropped.

Cibicides Montfort.

Sessile forms with flat or irregular ventral side. Dorsal side often very much convex or conical, often involute, so as to cover all former whorls. (This description of the situation by Brotzen, 1942, p. 21 is totally erroneous; his dorsal side (Spiralseite) in reality is the ventral one; this side often is conical, and here the chambers often are totally overlapping; the error has been made probably in considering the situation in *Cibicidoides,* in which genus the overlapping side is at the real dorsal side; many former authors also have given a total erroneous description of the real situation. In *Cibicides* always the dorsal or spiral side is nearly flat, at least in respect to the level of the roofs of the chambers; secondary layers of chalk material may alter conditions considerably. At the ventral side real *Cibicides* always shows overlapping chambers, as, deriving from *Parrella,* this species shows no umbilical cavity). Aperture as in *Cibicidoides* (which is not the case in reality), only that the umbilical mouth can be traced only in the last-formed chamber (which is not according to facts). In case that the umbilical mouth is lengthened, short sutural slits are found, giving rise to unreal lips (here the author confounds ventral with dorsal side).

As I have shown here, Brotzen's description of the genus is totally erroneous. Cushman's description of the genus from 1928 (The Foraminifera, p. 323) is much better:

"Test plano-convex, usually attached to various objects by the flattened dorsal side, trochoid; wall calcareous, coarsely perforate; aperture peripheral, at the base of the chamber, sometimes extending ventrally, but typically with a long slit-like extension between the inner margin of the chamber on the dorsal side and the previous whorl nearly or fully the length of the chamber."

In order to solve these entanglements, I have studied structurally the following species of real *Cibicides*:

Cibicides excavata Brotzen from the Maestrichtian chalk; *Cibicides pseudohaidingeri* nov. spec. from the Paleocene of the Netherlands; *Cibicides cryptomphalus* Ten Dam (*Cibicidoides proprius* Brotzen) from the Paleocene of the Netherlands; *C. refulgens* Montfort, *C. akneriana* (d'Orbigny), *C. wuellerstorffi* (Schwager), *C. margaritifera* (Brady), *C. mundula* (Brady, Parker et Jones), *C.equipunctata* nov. spec., *C. ungeriana* (d'Orbigny) and *C. hyalina* nov. spec. all from the Pacific, together with *C. ariminensis* (d'Orbigny), *C. foveolata* (Brady), *C. pseudoungeriana* (Cushman), all from the West-Indian region.

In consequence of these studies, I am able to define the genus *Cibicides* as follows:

Test from bi-convex to planoconvex, or even flat on both sides. At dorsal side always all chambers of all whorls visible, except in those cases, in which thick layers of secondary chalk cover the initial parts. At ventral side the chambers overlapping, mostly totally, but in some cases this overlapping is not total. In that case the species often have been called *Planulina* or *Anomalina*. Always the walls are thick, especially at the dorsal side, and in most cases opaque, brownish or greyish. Only deuteropores, which are often limited to the dorsal side; in those cases, in which pores are found at the ventral side, they are here more scattered and often restricted to the marginal parts. Aperture a sutural or slightly areal slit at the suture, always found at the dorsal half of the ventral suture, and often even submarginal or marginal. The latter is the case in those forms, in which the test is flattened (*Planulina, Anomalina*). No real umbilical cavity is found, not even in *C. excavata.* Often the apertural border is thickened with a lip which may extend toward the margin or even at the spiral suture on the dorsal side. In many species the dorsal side is totally flat (*C. lobatula* and *C. refulgens* from the North-Atlantic), and in those forms the ventral side is the convex one; then the dorsal prolongation of the apertural lip is very large, even extending backward to the suture of the former chamber. In later chambers this slit secondarily is closed by chalk material.

Anomalinoides Brotzen, 1942.

As Brotzen remarks in his work 1948 (Sver. Geol. Unders., Ser. C. No. 493, p. 86) it is "in many cases very difficult to limit the genera *Cibicides* and *Anomalinoides*". This points against the maintaining of this genus. The description of the genus runs, shortened, as follows (1942, p. 23):

Test often with rounded margin, symmetrically convex, coiling apparently planospiral. Spiral side largely involute, umbilical side evolute (here Brotzen confounds dorsal and ventral side, as in reality the ventral side is involute; this difference between dorsal and ventral sides can only be solved in transverse sections). Aperture interiomarginal septal, with extension into the umbilicus (this has to be read: into the dorsal cavity); umbilical opening covered with lip or rests of a lip.

These forms may lead to those which have been called hitherto *Nonion umbilicatula.* Sections of *Anomalinoides cryptomphalus* from the Paleocene of the Netherlands showed me, that they do not differ in any respect from typical *Cibicides,* but for the fact, that the chambers are more or less arranged in a planospiral spiral, and that consequently the aperture is marginal and the ventral chamberparts do not overlap the umbilical region totally. Those forms can be easily derived from forms as *Cibicides* *excavata* from the Cretaceous; in that species the umbilical region does already show a slight cavity, which, however, is not a primitive one, but a secondary development.

In those forms, in which the ventral side is even more flattened, as in *Planulina* and *Anomalina,* the inner structure shows no real difference with those, described as *Anomalinoides.* It may be convenient, to distinguish between close-coiled and small species (*Anomalinoides*), flattened species with more or less sharp margin (*Planulina*) and flattened larger forms with rounded margin (*Anomalina*) but in reality these forms are no real genera, as it often occurs, that one cannot decide whether a species is belonging to *Anomalinoides, Anomalina* or *Planulina.* So it will be clear that from a systematical and biological point of view it is much better, to drop all those so-called genera, and limit oneself to the genus *Cibicides.* In those cases, in which a larger umbilical cavity (often very much flattened) is found, one may decide to the name of *Anomalina.*

One group has been distinguished from the *Cibicidinae* by Brotzen, and has been called by him *Stensiöina* (1936). In that group the dorsal side is ornamented with very typical bosses and ridges, especially at the sutures. This dorsal side in most cases is flat, whereas the ventral side is often very much convex. In total view the genus resembles closely those species of *Cibicides,* which are known from recent seas having also an ornamented dorsal side, which is, however, not so flattened; viz. *C. foveolata* and *C. margaritifera.* But there is a striking difference between fossil *Stensiöina* and recent ornamented *Cibicides.* In all fossil species the ventral side shows distinct deuteropores, as is the case in Upper-Cretaceous *Gavelinella* (not in the Lower Cretaceous species, in which, as in recent *Gavelinopsis,* only protopores occur); but, as in Upper-Cretaceous *Gavelinella,* the dorsal side lacks pores totally. This is not astonishing: in Lower Cretaceous *Gavelinella* (*G. intermedia* e.g.) the fine protopores are also occurring at the ventral side only; so, as deuteropores always derive from protopores by gathering some of these pores together in a larger cavity of the thickened wall, only at the ventral side of *Gavelinella* deuteropores are able to develop. Now, in *Stensiöina pommerana* from the Upper-Cretaceous of the Netherlands, I found only pores at the ventral side, the dorsal side lacking them totally. Here only bosses of secondary chalk are found on the very much thickened walls. Transverse sections showed moreover, that the species has nothing whatever to do with *Cibicides,* as, equal to *Gavelinella,* the septal foramina are situated in the ventral half of the suture, and, in later-formed chambers, are connected with a ventral opening above the ventral lip, which covers partially the umbilical cavity, when existing. So, one cannot confound the two groups. *Stensiöina* is a Gavelinine genus, whereas ornamented *Cibicides* are real *Cibicides.* In real *Cibicides* the pores are developed especially at the dorsal side. But in ornamented *Cibicides,* as *C. foveolata* and *C. margaritifera,* the thickenings on the dorsal side lead to the consequence, that here pores are scattered and relatively rare; in these species at the ventral side pores, always deuteropores, have developed also, covering the whole ventral side of the chamberwalls. This would suggest some relation with *Stensiöina;* but the situation of the aperture, in *Cibicides* marginal with lip eventually still more marginal, in *Stensiöina* axial, with lip even umbilical, at once reveal the difference: in *Cibicides* the aperture is a protoforamen, whereas in *Stensiöina* it is a deuteroforamen.

It may be, that the study of these forms, as deuteroporous *Gavelinella* from the Upper-Cretaceous and of *Stensiöina,* has caused the error, made by Brotzen, to enclose the genera *Cibicides* and *Anomalina* (*Planulina*) into the group of *Gavelinella-Valvulineria.* They have, however, as stated above, nothing to do with this group.

Cibicides refulgens Montfort
(Figs. 233, 234)

This species, the type-species for the genus *Cibicides,* was found abundantly at St. 49a, 8° 23′ S., 119° 4′ E., depth 69 m. All specimens were rather small, the diameter not measuring more than 0,30 mm. The outer characters, together with the shape of the pores, however, are quite identical with those, found in typical *C. refulgens* from the North Atlantic, which I could study in the material from the Ingolf-Expedition.

Description.

At the dorsal side the test is nearly flattened, mostly with a sharp margin, while the ventral side is very much convex, with a slightly pointed umbilical region. At the ventral side relatively small deuteropores especially in the walls of the later chambers, size about 4 μ; the apertural face always is lacking pores totally. This face is more or less distinctly separated from the ventral side, as it forms an angle with it. At the dorsal side pores are very distinct in the last-formed whorl, but are

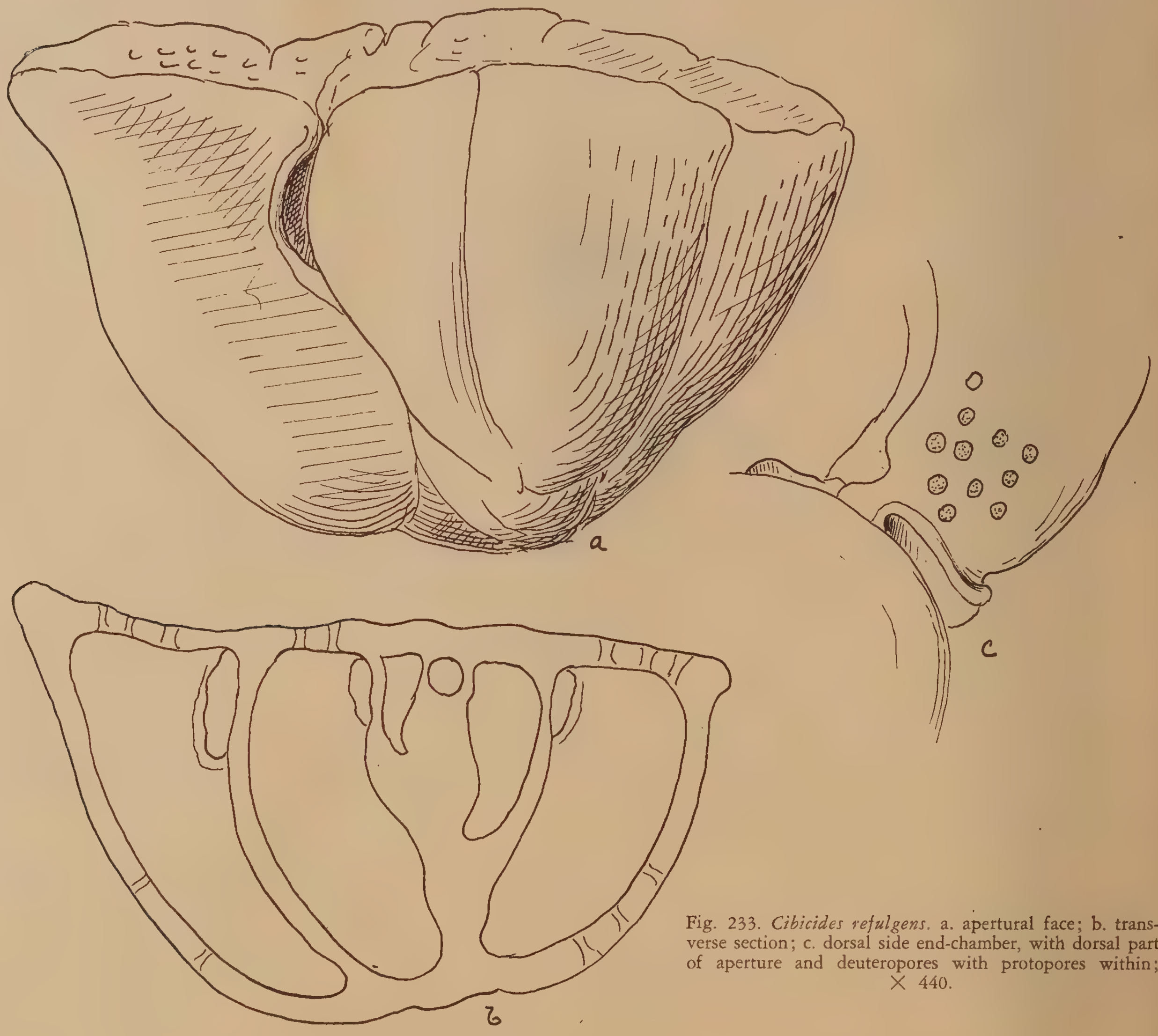


Fig. 233. *Cibicides refulgens.* a. apertural face; b. transverse section; c. dorsal side end-chamber, with dorsal part of aperture and deuteropores with protopores within; × 440.

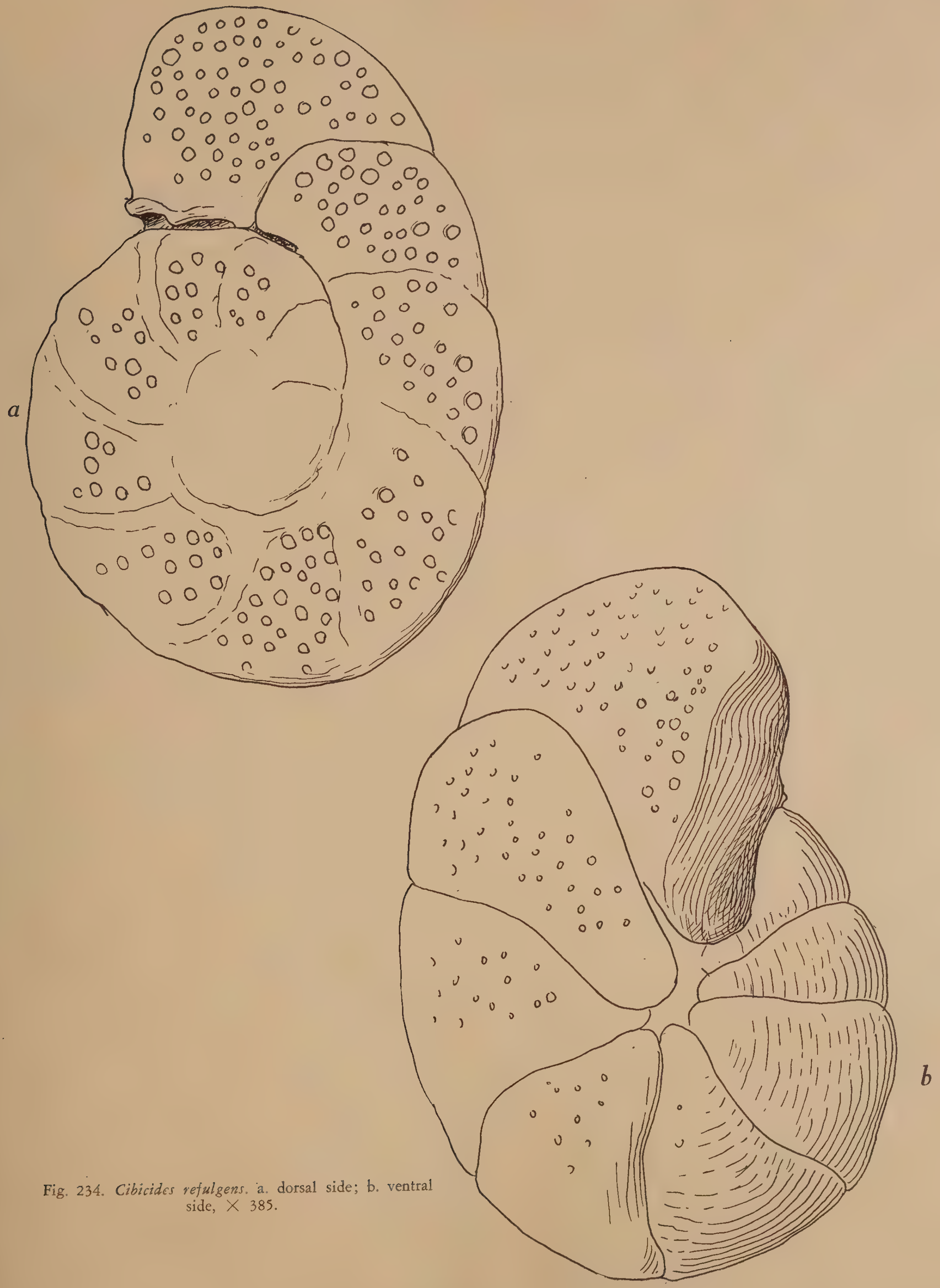


Fig. 234. *Cibicides refulgens.* a. dorsal side; b. ventral side, × 385.

closed and covered in the initial part by the thickening of the wall. These pores are much larger than those on the ventral side, measuring up to 8 μ. Often very clearly within the deuteropores the original wall is visible, in which the protopores can be traced. The walls are very opaque and in transmitted light show a dark greyish colour. The aperture is marginal and extends often along the dorsal suture of the chamber, never however reaching the proximal suture of it. The aperture is bordered by a somewhat protruding lip.

Length up to 0,30 mm in the material, thickness of test 0,15 mm.

Cibicides akneriana (d'Orbigny)

(Figs. 235, 236)

Several specimens were found at 43 fathoms depth at Station 5° 21′ N., 107° 14′ E., from H. M. S. Telegraaf. The numerous chambers in the last coil, the shape of the chambers and the overlapping of the chambers at both sides, which indicate a very close connection with those forms, known formerly as *Anomalina,* lead to the suggestion, that the tests belonged to the species *C. akneriana,* though one never can say with certainty without knowing inner conditions, which were never described by earlier authors.

The walls are hyaline, and thick, with rounded pores, measuring about 4-6 μ diameter. They occur at both sides, somewhat more rarely at the ventral one and at this side smaller than at the dorsal side. The aperture is anomaline, marginal, with tendency to run along the suture at the dorsal side. Dorsal and ventral umbilici filled up smoothly with hyaline chalk. Margin rounded. Number of chambers in megalospheric specimens about 12. Chambers nearly 2 × as broad as high, marginal end of chambers directed backward. Sutures somewhat sunken down, filled up with hyaline chalk, smooth. Diameter up to 0,30 mm in megalospheric form, thickness about 0,1 mm.

Cushman's description of the species runs as follows:

"Test free, biconvex; peripheral margin broadly rounded; dorsal surface convex at the margin, depressed or flattened toward the centre, ventral surface convex but less so toward the centre; chambers numerous, about 11-13 in the final coil, broad, short; sutures strongly limbate, ventrally depressed, sutures between last few chambers and the previous coil deep and distinct; surface very coarsely punctate; aperture an arched slit at the periphery. Diameter up to 1,25 mm.

Several specimens, obviously belonging to the same species, showed a flattened dorsal and a more bulky ventral side.

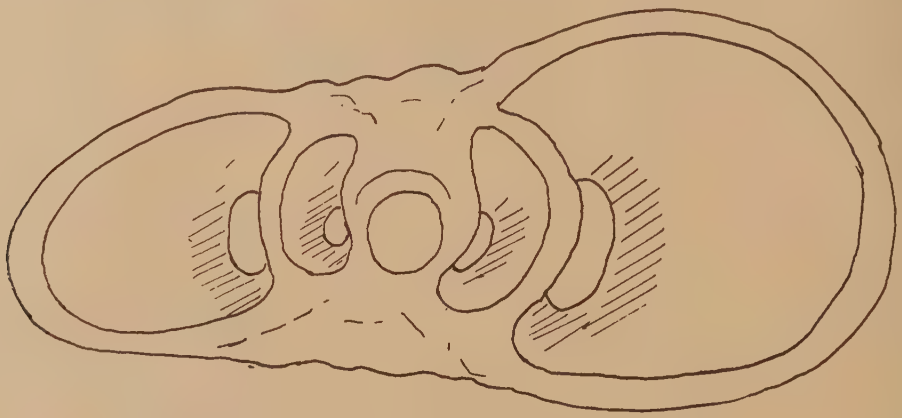


Fig: 235. *Cibicides akneriana.* Transverse section, dorsal side above; × 480.

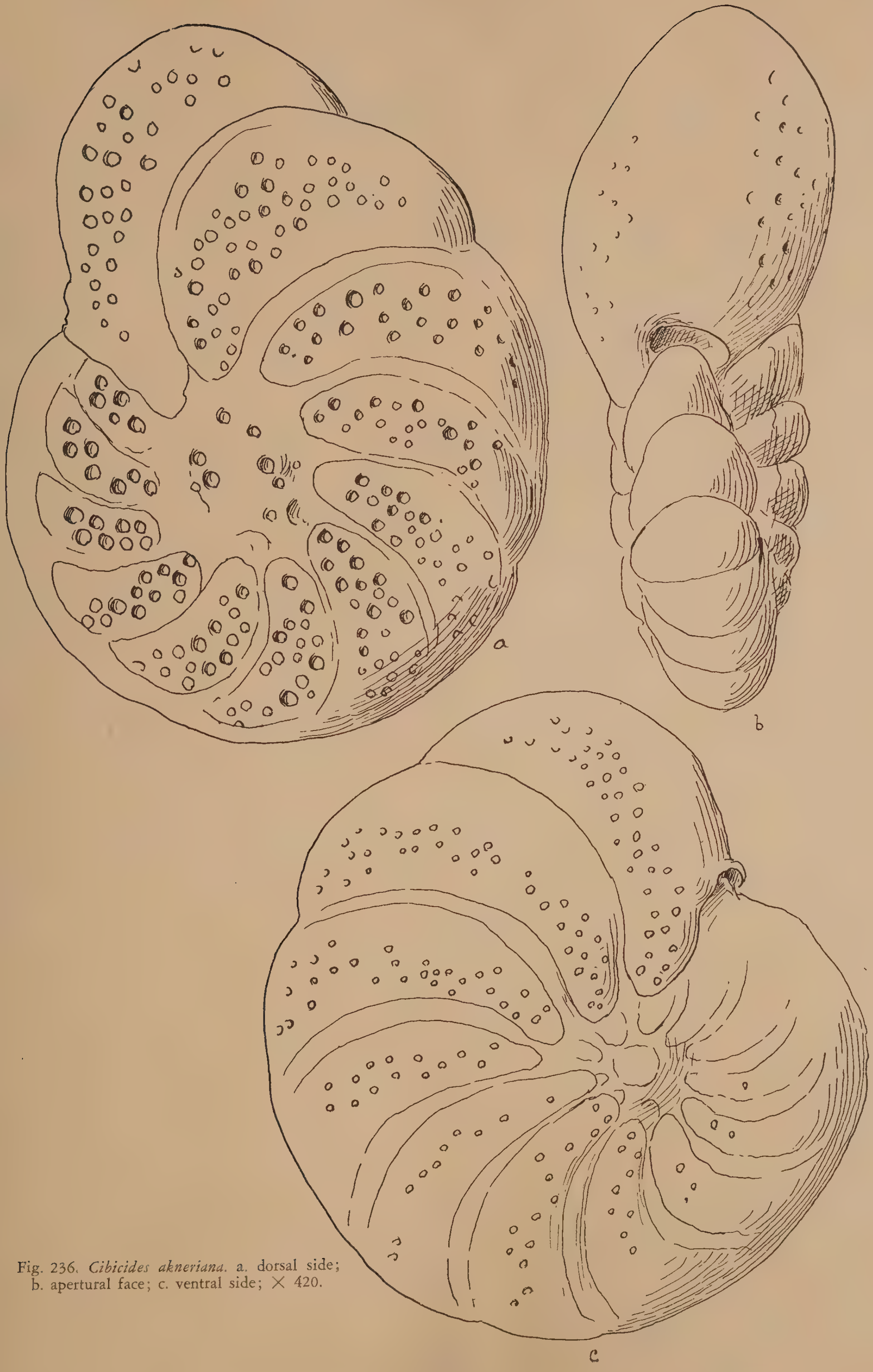


Fig. 236. *Cibicides akneriana.* a. dorsal side; b. apertural face; c. ventral side; × 420.

Cibicides wuellerstorffi (Schwager)
(Fig. 237)

The species occurred at many stations throughout the whole archipelago, especially at stations south of Sumatra, but also at those near Flores. It was found in depths ranging from 200 up to 700 fathoms.

The species is very difficultly distinguishable from *Anomalina* when considering only the descriptions, e.g. from *Anomalina ariminensis.* Only, in the latter the test is much more compressed than in most specimens of *Cibicides wuellerstorffi.* Yet there occur specimens of the latter species which are flattened on both sides too, especially in the A_1- and the B-generations. In the A_2-generation the species is much more inflated on the ventral side. When studying transverse sections, one finds, that the first-formed chambers show a trochoid spiral with the umbilicus directed towards that side which in the later part of the test is regarded as the dorsal one. The aperture on the contrary is always situated in such a way, that it rides on the margin of the shell, but with a lengthening towards this so-called dorsal side. Thus, in the genus *Cibicides* Cushman declares: "aperture peripheral, at the base of the chamber, sometimes extending ventrally, but typically with a long slit-like extension between the inner margin of the chamber on the dorsal side and the previous whorl nearly or fully the length of the chamber." Slides showed me, that here the slit-like extension runs nearly along the side of the chamber.

The pores on the dorsal side (the flattened side) of *Cibicides w.* are much larger than those on the ventral side; the latter are very irregularly formed, while those on the dorsal side show at least smooth walls. Those on the ventral side measure only 4 μ at the highest, while those on the dorsal side measure from 4-12 μ in diameter.

At the flat side the sutures, especially those between the older chambers and between the older coils show a thickening by secondary chalk, which covers partially the surface of the chambers, so that only few pores of them reach the surface. Thus thickening gradually increases as the test grows older, so that on transverse section growthlines can be seen. At the ventral side most of the umbilicus is filled up by the alar prolongations of the chambers, thus leaving only a very narrow part of the umbilicus on the ventral side free, which in megalospheric shells is filled up with secondary chalk-material, showing too these growthlayers.

In a large A_1-specimen the test was much more flattened, having some characteristics of *Anomalina ariminensis.* Here the dorsal and ventral sides in transverse section showed to be much more confused; the chambers were overlapping at that side, which was opposite to that, on which the chambers overlapped in the A_2-form, which could be most certainly demonstrated by the lip of the aperture which, in the A_2-specimen, showed its most projecting end towards the overlapping side of the chambers, whereas in the A_1-specimen it was found at the other, non-overlapping side. This clearly shows, that the term dorsal and ventral in *Cibicides wuellerstorffi* is a somewhat trivial expression.

As no microspheric specimens were found, and as in all gatherings (which is in agreement with Cushman's statement) the species always is very rare, no statistical study could be made.

We can, however, always call the side, lacking pores or having smaller deuteropores than the other one, the ventral side. Moreover in most species of *Cibicides* this side shows the more overlapping parts of the chambers. In *Cibicides ariminensis,* moreover, the margin is bluntly formed by a flat keel with two raised ridges, whereas in *C. wuellerstorffi* it is somewhat rounded.

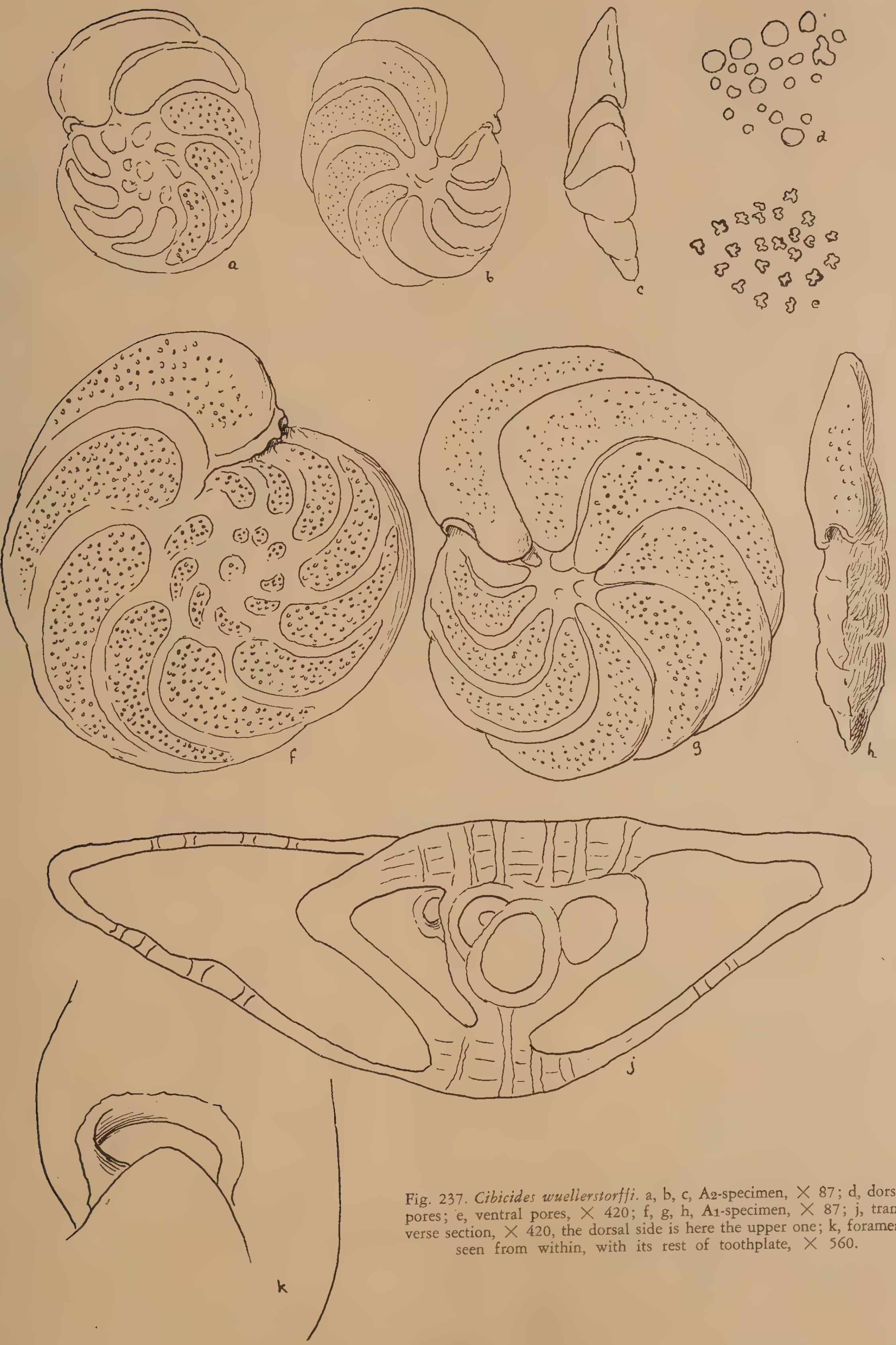


Fig. 237. *Cibicides wuellerstorffi.* a, b, c, A2-specimen, × 87; d, dorsal pores; e, ventral pores, × 420; f, g, h, A1-specimen, × 87; j, transverse section, × 420, the dorsal side is here the upper one; k, foramen, seen from within, with its rest of toothplate, × 560.

The foramina of this species always show a thickened border with a curved ridge at the inner side of the wall. It may be, that this thickening is a rest of the toothplate; it is always found at the ventral side, thus situated axially from the aperture. This would be in agreement with our views, that the foramina are protoforamina.

Cibicides margaritifera (Brady)
(Figs. 238, 239)

This species was not recorded by Millet from the East-Indian Archipelago, but I found it in several gatherings south of Sumatra, e.g. at 2° 17′ S., 99° 27′ E., from 377 fathoms. It was never occurring in the gatherings than with only few specimens, so I could not give data about bionomics. Yet I could study structural peculiarites. At the dorsal side the sutures are covered in the older chambers by buds of secundary chalk, at the ventral side the sutures are filled up by smooth chalk-material. Dorsally and ventrally the walls show rather coarse pores, equally wide dorsally and ventrally. They have a diameter of 4-6 μ. The shell itself is built up by somewhat opaque chalk which, however, in thinner layers is nearly hyaline. The apertural face of the shell shows no pores. The aperture is a somewhat oblique arched slit, very short, and reaching the margin. The first chambers in transverse

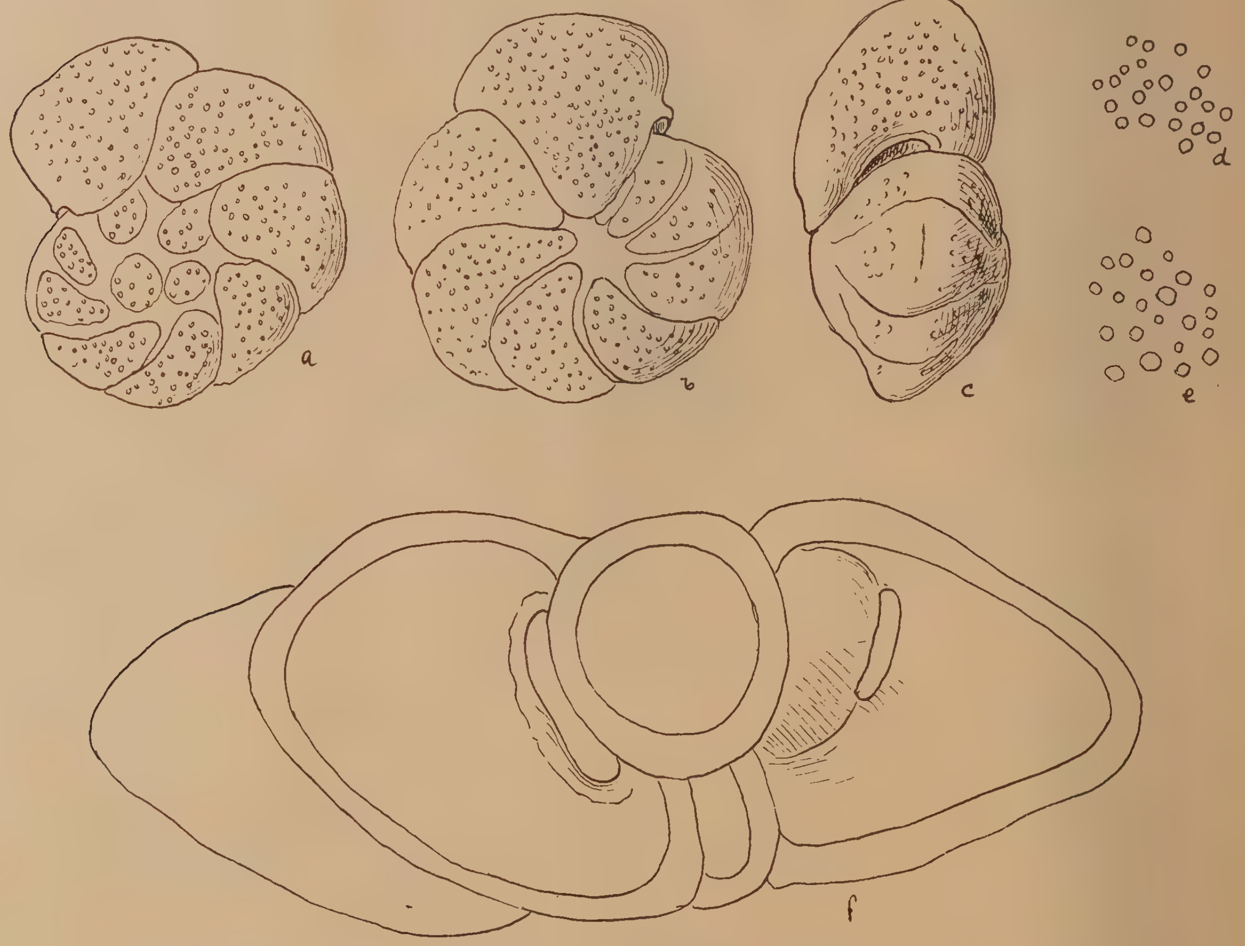


Fig. 238. *Cibicides margaritifera.* A_2-specimen; a, b, c, three views; × 95; d, dorsal pores, e, ventral pores, × 480; f, transverse section, × 465.

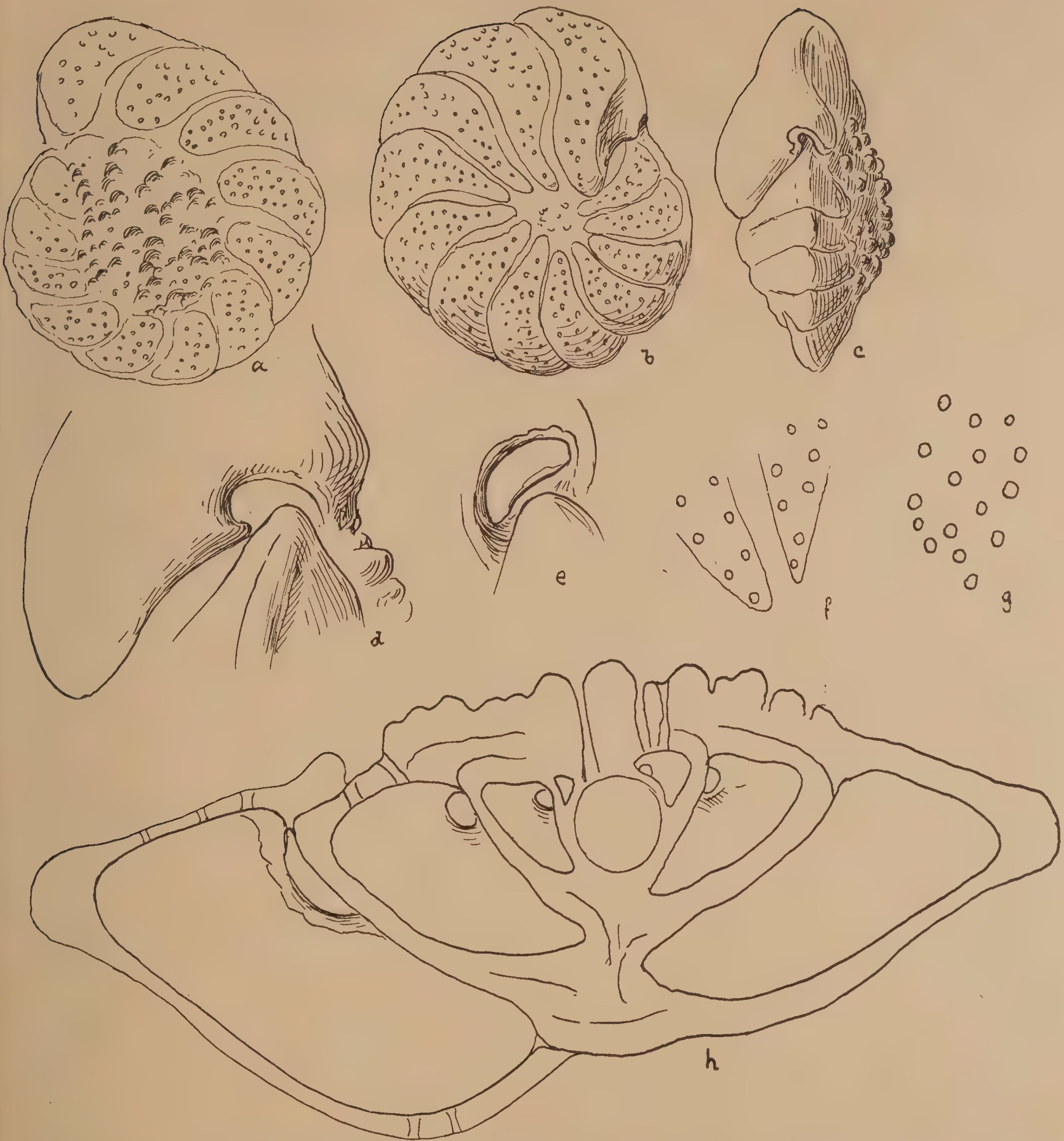


Fig. 239. *Cibicides margaritifera.* A1-specimen; a, b, c, three views; d, aperture; e, septal foramen from the inside; f, ventral pores; g, dorsal pores; h, transverse section, all × 465.

section of a megalospheric specimen show very clearly, that the dorsal side is nearly flat, and that the chambers overlap the earlier ones nearly up to the centre of the umbilicus. Here clear shell-substance is laid down to fill up the umbilical hollow smoothly and totally.

The tests found were of smaller size than those, mentioned by most authors. A megalospheric test had a diameter of 0,40 mm.

A specimen, apparently of A2-generation, showed some peculiarites which the other specimens did not show, being of A1-form. Dorsally the centre of the shell was covered by an opaque mass of secundary chalk, as if the margaritiferous knobs were melted together. At the ventral side only very few pores were traced, the transparent walls of the side being mostly totally smooth. The proloculus, with a diameter of 63 μ, was followed by a second chamber, only separated from it by means of a thin wall, indicating, that the embryo was two-chambered.

The proloculus of the other A-generation measured 38, 28, 28 and 36 μ in diameter.

Cibicides mundula (Brady, Parker et Jones)

(Figs. 240, 241)

The species occurred in some specimens in gathering south of Sumatra at 2° 17′ S., 99° 27′ E., depth 377 fathoms. They showed all to be megalospheric, and no statistical statements could be made. But the outer and inner structure could be fairly established. The species was found also at 2° 6′ S., 99° 54′ E., 778 fathoms.

The dorsal side is, especially in older individuals, covered by smooth, though somewhat opaque, shell-material, so that only very few pores can be found in the centre; in older individuals no trace of pores in the centre can be discovered. The sutures of the walls equally are filled up by this material, which lies somewhat thickened on the surface. The pores on the dorsal side are coarse, as in all species of *Cibicides,* and the secundary chalk in the central part surrounds the pores. In young specimens of typical A2-generation (inner diameter of proloculus about 46 μ) those pores on the dorsal side have a diameter of 6-10 μ; in individuals of the A1-generation, which are older and larger (0,40 mm) those pores of the last-formed chambers are smaller, as the secondary chalk has not yet thickened the walls and consequently widened the pores, and they show a constant diameter of 4 μ.

On the ventral side the chambers do not reach the centre, which is filled up with the same smooth, but opaque secundary chalk which covers the umbilicus smoothly and streams down the sutures, filling them up too, but not thickening the walls. Those walls of the ventral side in young megalospheric specimens are totally deprived of pores, very hyaline, so that the dorsal side can be seen in transmitted light. In older specimens hyaline pustules, which may be taken as irregular pores, are found on the later chamberwalls on the ventral side of the shell. They have a diameter of about 6 μ, so they are distinctly larger than the pores on the dorsal side.

In younger shells the aperture forms an arched slit, just ventrally to the margin, and short, as in all real *Cibicides.* But in the older shells in the later formed chambers this aperture creeps up towards the margin, and becomes marginal, as in the "genus" *Anomalina.* In very old shells the aperture may be even found dorsally. Here we find, that the typical characteristic of the genus is not constant as it is likewise in other species of the genus; this leads to the conclusion, that the ventral situation of the aperture cannot be taken as a good characteristic for the genus.

The chambers are, in transverse section, low and broad, extending straightly towards the ventral side. Dorsal and ventral side are equally biconvex, and the margin shows a rounded, hyaline carina, which gives the chambers a peculiar form in transverse section. The dorsal side is smoothly covered by the secundary chalk which is laid down in distinct layers. At the ventral side the umbilicus is broad, as the chambers do not bend towards the umbilical region. Here likewise the chalk, filling up the umbilicus, is opaque, but very homogeneous, and forms a smooth knob in the centre.

Diameter of A_2-specimens up to 0,30 mm, thickness of tests here 0,13 mm; diameter of A_1-specimens 0,45 mm, thickness 0,20 mm.

Tests remind of *C. ungeriana,* but can easily be distinguished by the margin which in *C. mundula* is hyaline and relatively sharp, though not really keeled, whereas in *C. ungeriana* it is rounded and consequently not hyaline in transmitted light. Moreover the number of chambers in the last-formed whorl in *C. mundula* is 10-11, in *C. ungeriana* it is 7-9.

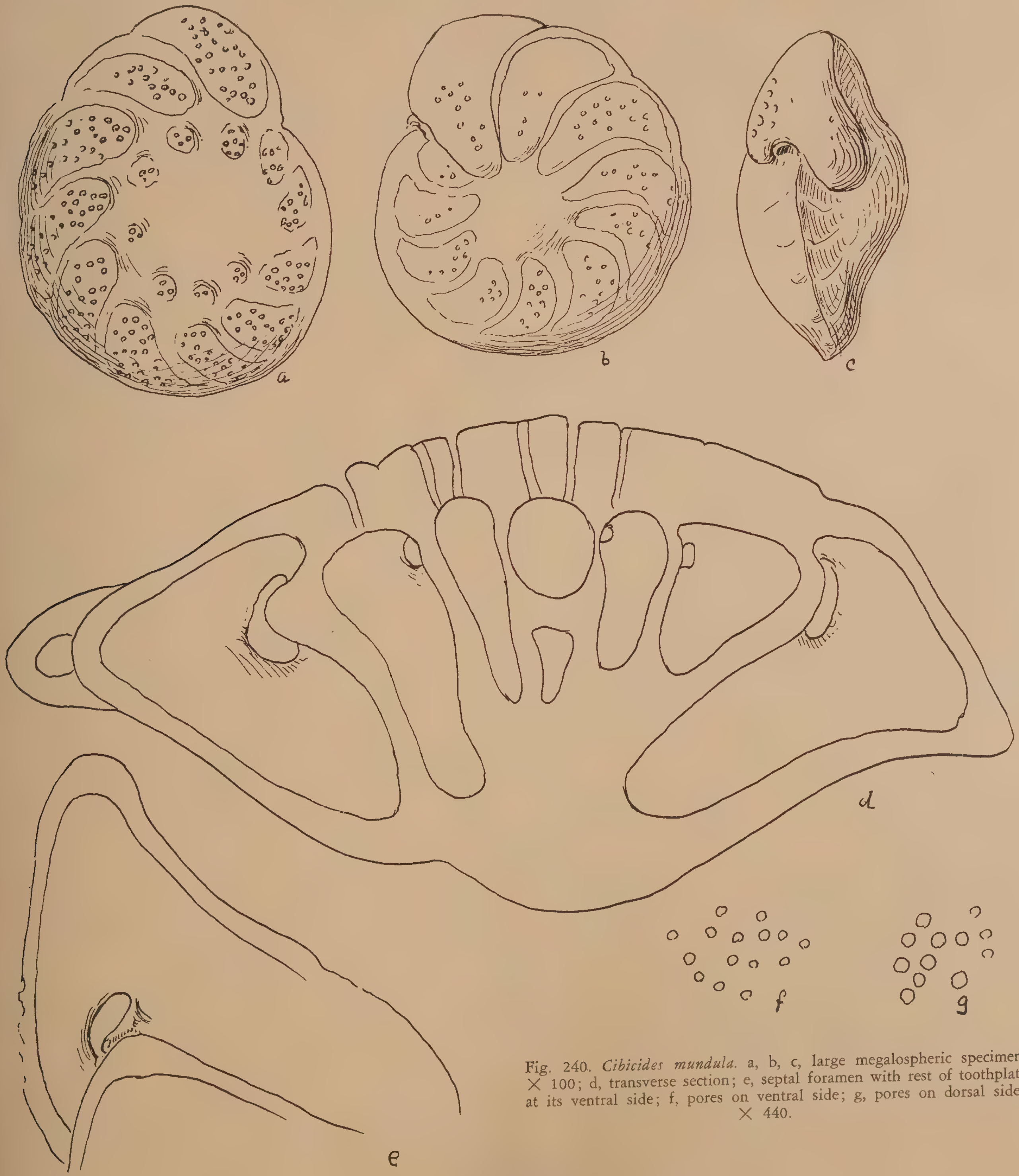


Fig. 240. *Cibicides mundula.* a, b, c, large megalospheric specimen, × 100; d, transverse section; e, septal foramen with rest of toothplate at its ventral side; f, pores on ventral side; g, pores on dorsal side; × 440.

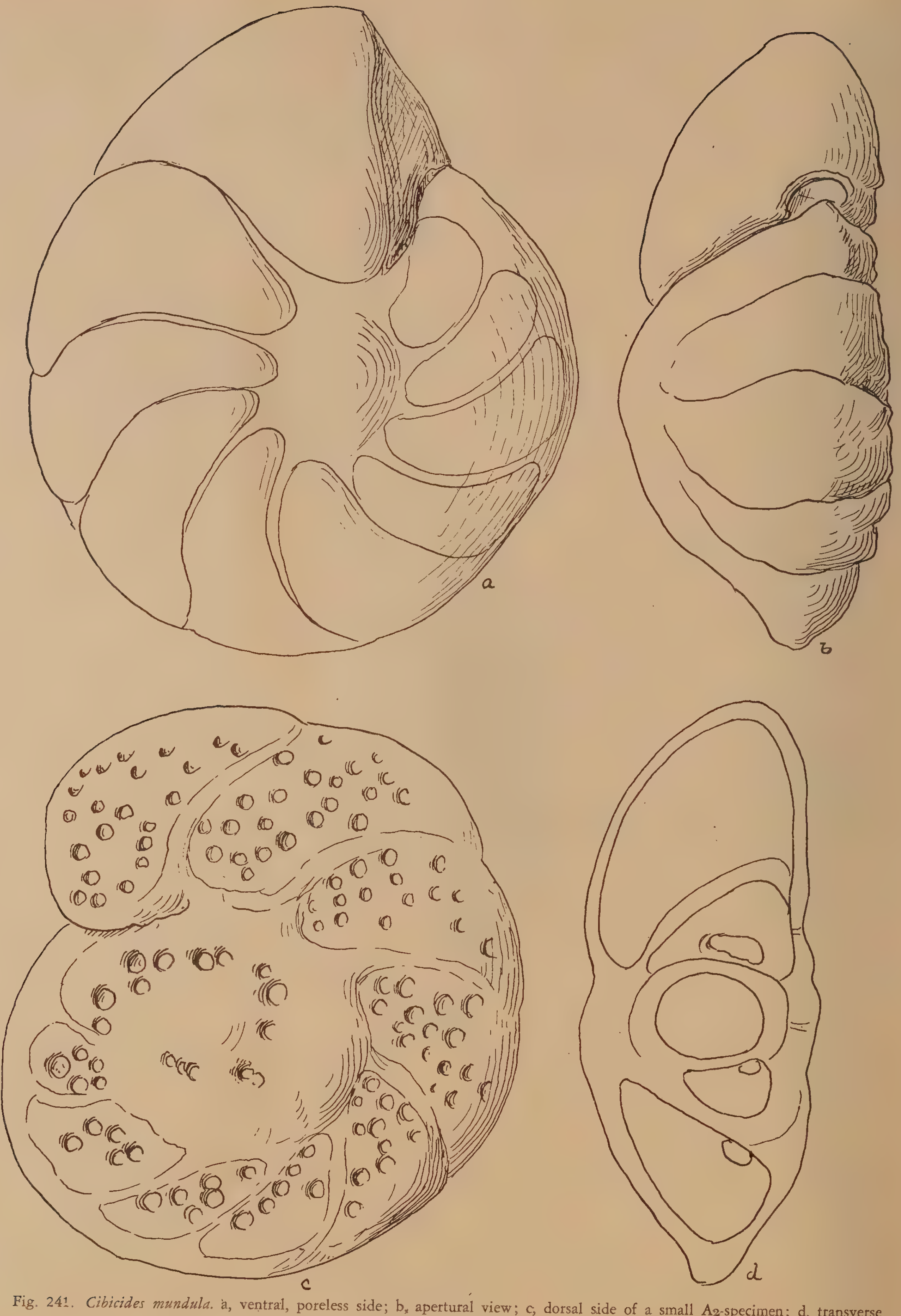


Fig. 241. *Cibicides mundula.* a, ventral, poreless side; b, apertural view; c, dorsal side of a small A_2-specimen; d, transverse section. All × 432.

Cibicides ungeriana (d'Orbigny)
(Figs. 242, 243)

One of the most common species I believe to belong to this genus, though descriptions are most superficial and incomplete. The rounded margin, the typical aperture with pronounced lip, the coarse pores on the dorsal side and the opaqueness of the shellwalls (in transmitted light the walls are nearly blackish), together with the compactness of the whole shell and the number of chambers of the lastformed coil are typical enough. Cushman created a new species for those forms, found in the West-Indian regions, viz. *Cibicides pseudungeriana.* It is easily distinguishable from all other *Cibicides* when seen in transmitted light, imbedded in some clarifier; then the shell is not, as in other species of the same genus, yellowish, or hyaline, but deep greyish in colour.

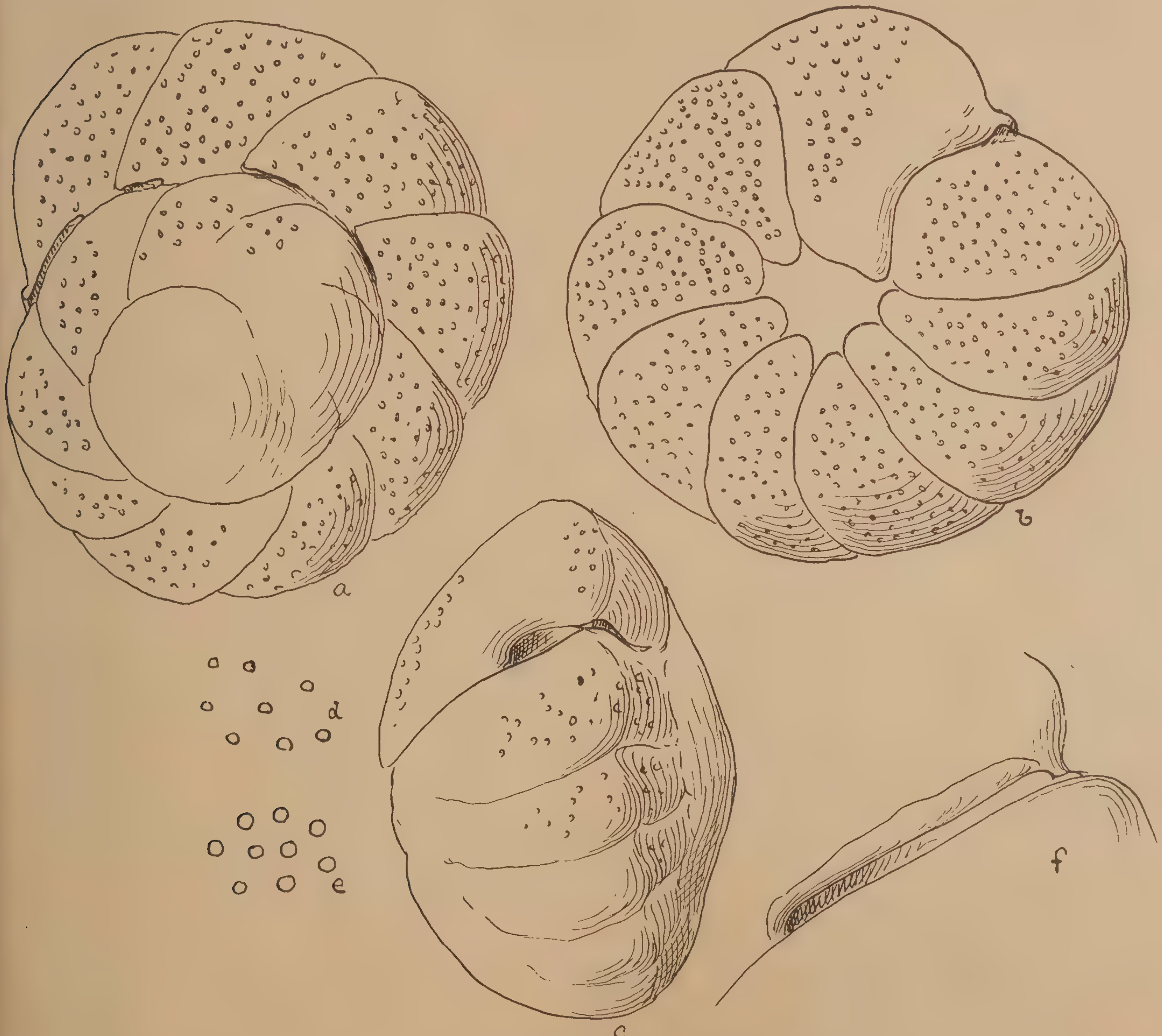


Fig. 242. *Cibicides ungeriana.* a, b, c, megalospheric specimen, × 95; d, pores of ventral side; e, pores on dorsal side; f, aperture; × 475.

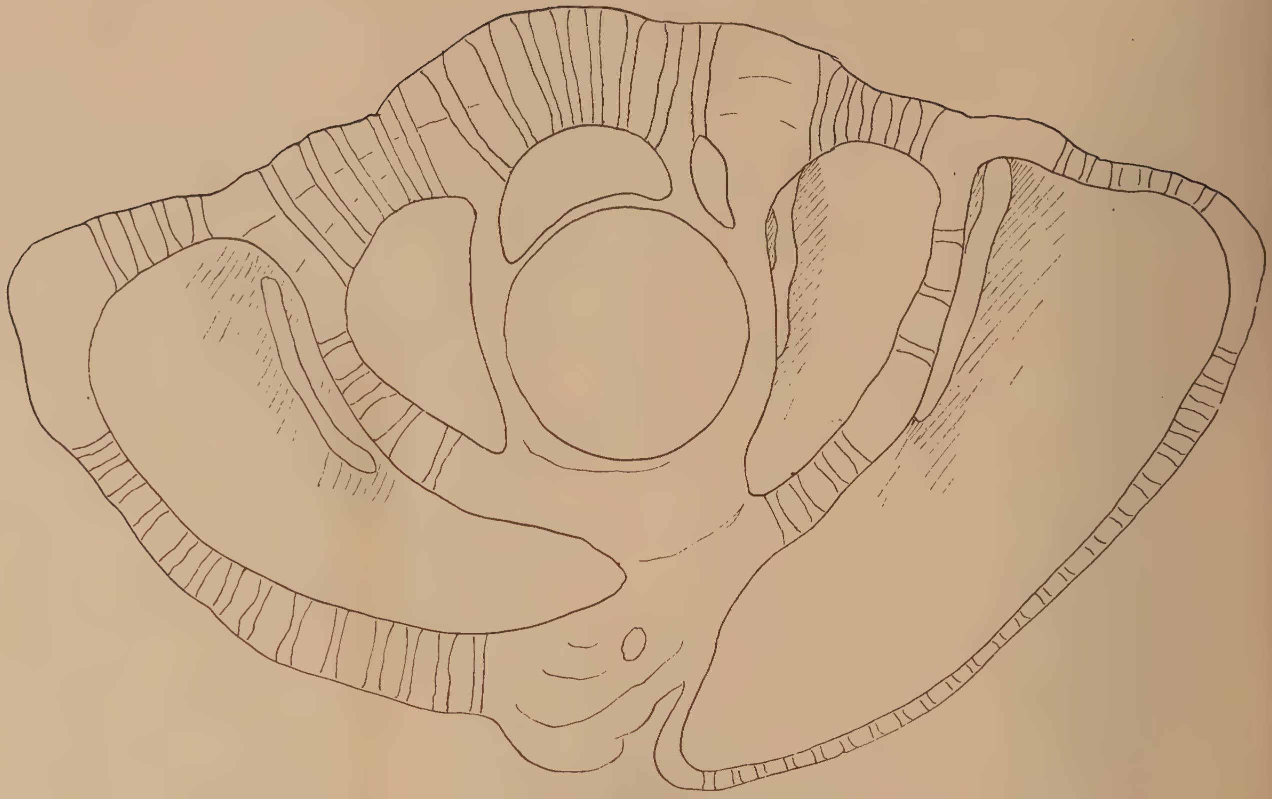


Fig. 243. *Cibicides ungeriana.* Transverse section through megalospheric specimen; × 320.

On the dorsal side only the chambers of the last-formed coil are clearly visible, the central chambers always being covered by thick smooth layers of secundary chalk. The sutures are somewhat rounded and slightly compressed. The last-formed chambers show the pores clearly, and those pores have a diameter of about 3-5 μ. The margin is always rounded, seldom more acute. The dorsal side always is convex, but less than the ventral side. The aperture is a narrow, long slit, beginning half up the ventral suture, creeping over the margin, and ending half way the dorsal spiral suture. It shows a somewhat protruding lip. In older chambers the septal foramen is separated from the dorsal slit, and the latter soon becomes filled up by the secundary chalk which covers the sutures.

At the ventral side the chambers overlap the foregoing coils, leaving a comparative narrow umbilicus free. This umbilicus is filled up with the same opaque secundary chalk, which often protrudes somewhat in a central knob. Sutures at the ventral side slightly curved, but never s-shaped, as in *C. margaritifera.* All specimens observed were of the A$_2$-generation, with a very large proloculus of about 110 μ diameter, followed by a second chamber, and separated from this chamber by a very thin wall. It is very probable, that the embryo is two-chambered. The second chamber often is placed dorsally from the proloculus. In transverse section the species is recognisable by the long slitlike foramina of the chambers which are scarcely found in other species of this genus.

The species was found in more considerable number in the following stations:

2° 56′ S., 99° 38′ E., 405 fathoms
St. 260, 5° 36′ S., 132° 55′ E., 90 meters
2° 17′ S., 99° 27′ E., 377 fathoms
5° 21′ N., 107 ° 14′ E., 43 fathoms
2° 6′ S., 99° 54′ E., 778 fathoms.

Cibicides hyalina nov. spec.
(Figs. 244, 245)

It is possible, that this species has already been named; but descriptions are so very inaccurate, that it is quite impossible to refer shells to one description or to another. So it may be, that this species is in some forms identical with *C. tumida,* but the tests are never deeply brown; or even with *T. pygmaea,* but the aperture in megalospheric form is no slit. So I called the species which is fairly common in gatherings south of Sumatra, from 200 to 700 fathoms, *C. hyalina.*

I found specimens with a relatively large proloculus, with a diameter of the proloculus of about 37 μ, together with other shells with a proloculus of only about 15 μ. Both seem to be megalospheric; microspheric shells could not be found.

Forma A_1. Dorsal side very convex, smooth and shining, showing through the clear shell-substance all chambers, though the centre is thickened. Nearly 5 coils of chambers; margin somewhat lobulate, very much rounded; sutures oblique, rounded somewhat, smooth, but very slightly compressed. Ventral side convex, but not so strongly as the dorsal side, somewhat concave in the centre. Sutures slightly s-shaped, centre filled up with clear shell-substance, radiating along the sutures towards the middle of the chamber. At the dorsal side pores are found, measuring about 4-6 μ, while at the ventral side the pores are much smaller, with diameter only 2 μ. The central parts of the chambers show no pores at all on the ventral side.

Forma A_2. Dorsal side highly convex, smooth and shining, showing all chambers, showing 3 coils of them. Centre less thickened than in the other form. Pores of the dorsal side 4-6 μ diameter. Margin lobulate, not so bluntly rounded as in the A_1-form. Sutures oblique, very slightly compressed, smooth. Ventral side convex throughout, nearly as strongly as the dorsal side. Sutures straight or slightly s-shaped, centre filled up by clear shell-material, radiating along the sutures till half the chambers, or more. Only the older chambers show some pores which are as coarse as those on the dorsal side. Ventral side thus mostly totally lacking pores, chambers not so inflated at the ventral side as in the A_1.

Both generations show a very small, rounded aperture just below the margin. No dorsal lengthening of this aperture along the sutures.

The shells are characterized by the shining, translucent and extraordinary clearness of the walls. Diameter of both forms about 0,30 mm.

The species only occurred in the gatherings, South of Sumatra, never in those of the eastern part. Statistic measurement gave following data.

A_2-generation: diameter of test from 0,15 to 0,25 mm, proloculus from 27 to 41 μ, total number of chambers from 13-21, average 19; number of chambers in last whorl 6-8, mostly 6.

A_1-generation: diameter of test from 0,20 to 0,30 mm, proloculus from 12 to 25 μ, total number of chambers from 23 to 39, average 30, number of chambers in last whorl 7-9, average 8.

No B-specimen was found among 18 specimens. The A_1 and A_2-generations in a diagram were distinctly separated.

The species may have been confused hitherto with *Truncatulina dutemplei* Brady (not d'Orbigny), which has been renamed by Trauth, 1928 in *T. bradyi.* My specimens constantly showed however a much higher spiral side.

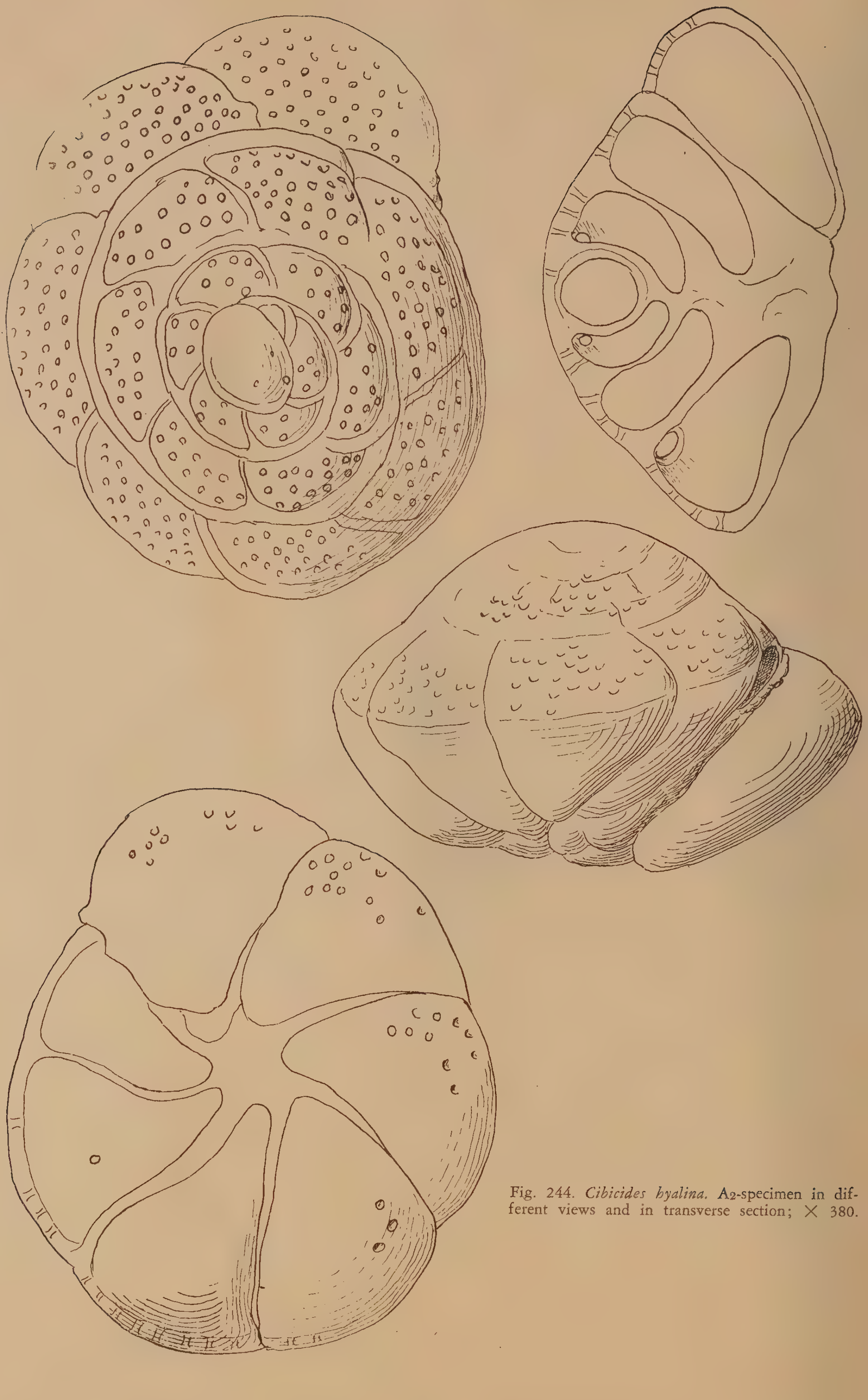


Fig. 244. *Cibicides hyalina.* A2-specimen in different views and in transverse section; × 380.

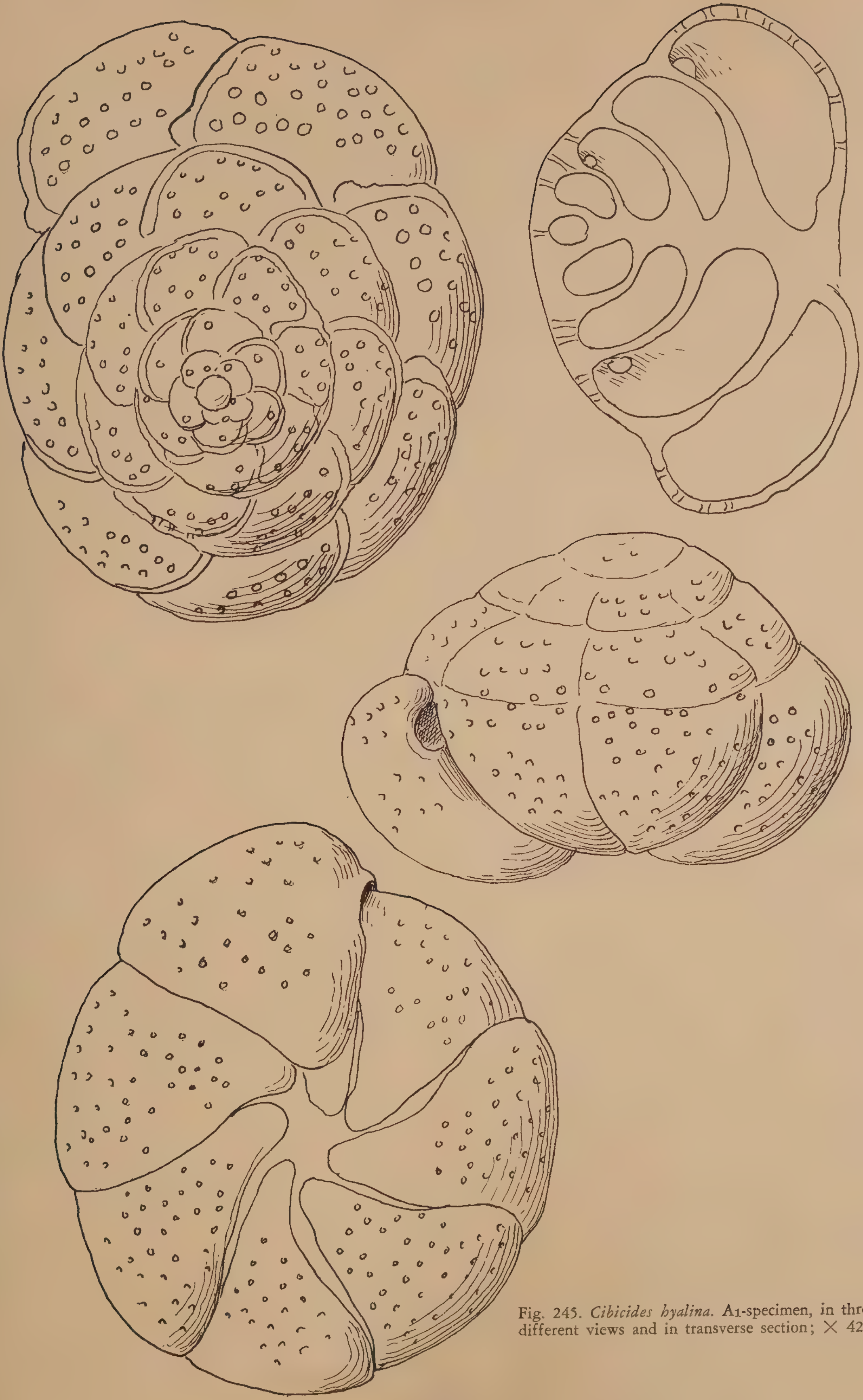


Fig. 245. *Cibicides hyalina.* A1-specimen, in three different views and in transverse section; × 420.

Cibicides equipunctata nov. spec.

(Figs. 246, 247)

A very fine species occurred in several specimens in gathering 2° 17′ S., 99° 27′ E., depth 377 fathoms; together with five megalospheric specimens, one microspheric specimen was found so that the species can be described. It was found too at 9° 17′ S., 120° 13′ E., 320 fathoms. It is very probable, that it has been mentioned by authors as *Anomalina grosserugosa,* as the microspheric resembles this species; but the megalospheric form shows all characteristics of real *Cibicides,* it has to be classed in that group.

B-generation. Diameter 0,75 mm. In the dorsal side the chambers are somewhat overlapping; this side is nearly flat. Last formed chambers somewhat recurring at the margin with a distinct hook. Central part covered with thick hyaline secundary chalk, leaving only few pores from the first coils free. Aperture an oblique slit, arched and short just about the margin, showing the features of an *"Anomalina".* The aperture shows a well developed lip. Apertural face with pores which are on both sides, ventral and dorsal, equally distributed and of quite the same size, measuring from 2-4 μ in diameter. Ventral side convex, chambers overlapping here, but leaving a wide umbilicus free, filled up with a hyaline knob of chalk, somewhat protruding. Sutures on both sides depressed and on the ventral side showing a peculiar hook in the last-formed chambers, tending to the structure of *Cibicides wuellerstorffi.* Sutures very slightly rounded, nearly radial.

In transverse section the proloculus has a diameter of 8 μ, while all chambers show the short, arched foramen, riding on the margin. Chambers with a prolongation towards the ventral side, as usual in *Cibicides* but tending to grow out dorsally in respect to the level of the proloculus, as in *"Anomalina".* No real apertural lengthening at the dorsal sutures, but a distinct ridge, formed by the chamberwalls, which may suggest such an opening. The dorsal walls in the centre are very much thickened, so that the dorsal side becomes totally flattened; at the ventral side the mentioned hyaline filling-up of the umbilicus.

A-generation. Only shells with very large proloculus, obviously belonging to the A_2-generation, could be found. The tests differ considerably from the microspheric form, but the texture of the shell, with the typical equally distributed pores, the thin walls of the last-formed coil of chambers, the growing backwards at the sutures of the last-formed chambers, the hyaline shell-substance, coloured brownish-yellow, all are the same, so that I do not hesitate to consider these megalospheric shells as belonging to the same species. The dorsal side shows less amount of secundary chalk in the centre, so that all chambers can be seen easily. Only the sutures show secundary thickening. The chambers here too are somewhat overlapping. The apertural face likewise is covered with pores, and the pores on the dorsal side are very slightly larger than in the microspheric form, but those at the ventral side measure 2-4 μ. They are likewise very equally distributed all over the surface. The aperture however is situated marginally; but very clearly ventrally, and is not a short slit, but a narrow and low slit, extending to the middle of the total breadth of the shell, much more truncatuline than in the microspheric form, where it is anomaline. The proloculus has a diameter of about 58 μ, and is followed by only 1½ coil of chambers, whereas in the microspheric form 3½ coils are formed. In the megalospheric form the dorsal side is somewhat flattened, but the sutures are more depressed, while the narrow umbilicus does not show much filling-up with secundary chalk.

Number of chambers in microspheric form in the last-formed coil 11; that in the megalo-

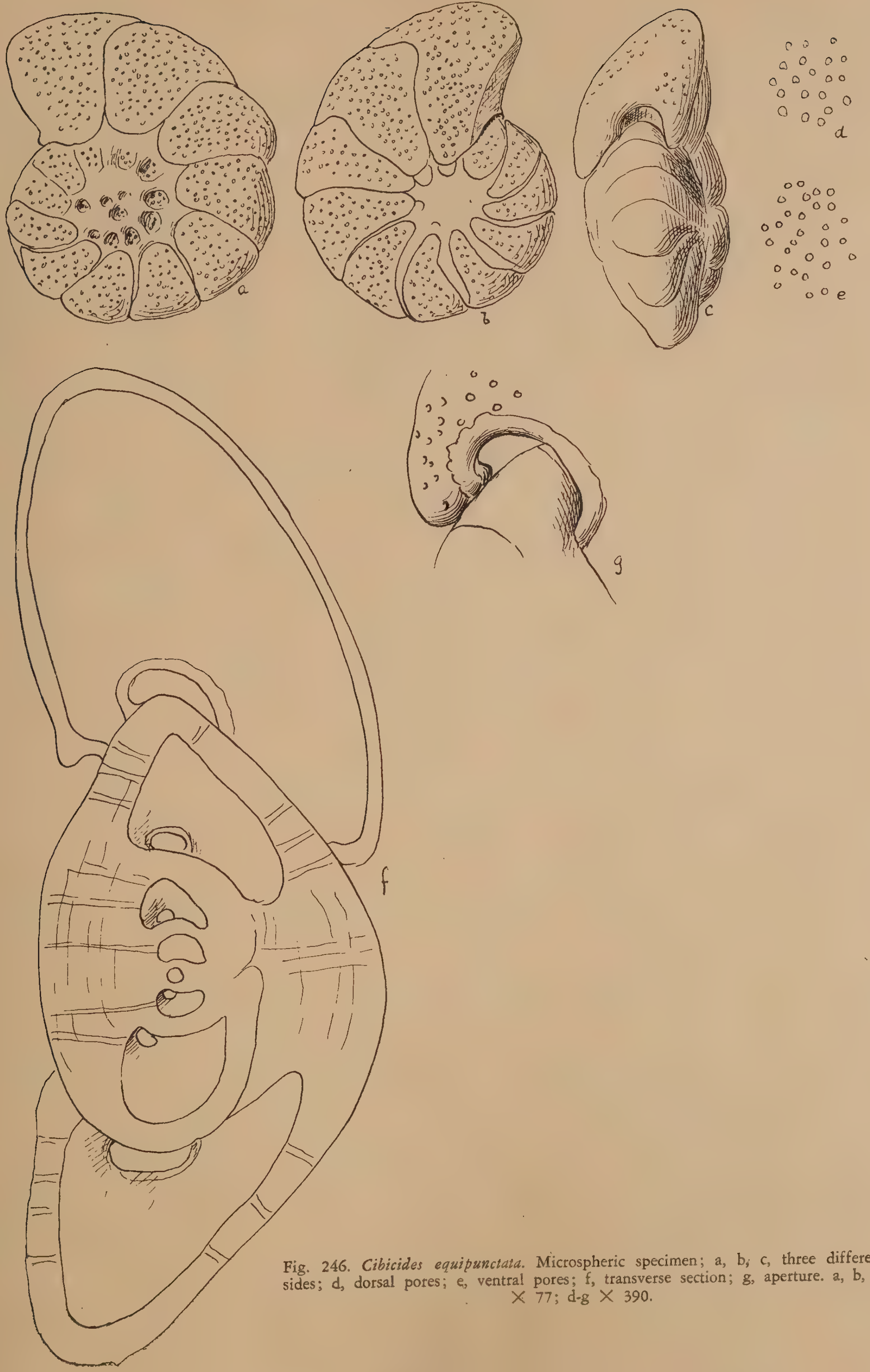


Fig. 246. *Cibicides equipunctata.* Microspheric specimen; a, b, c, three different sides; d, dorsal pores; e, ventral pores; f, transverse section; g, aperture. a, b, c, × 77; d-g × 390.

spheric form only 8. Diameter of megalospheric form up to 0,55 mm. Colour of shells brownish-yellow.

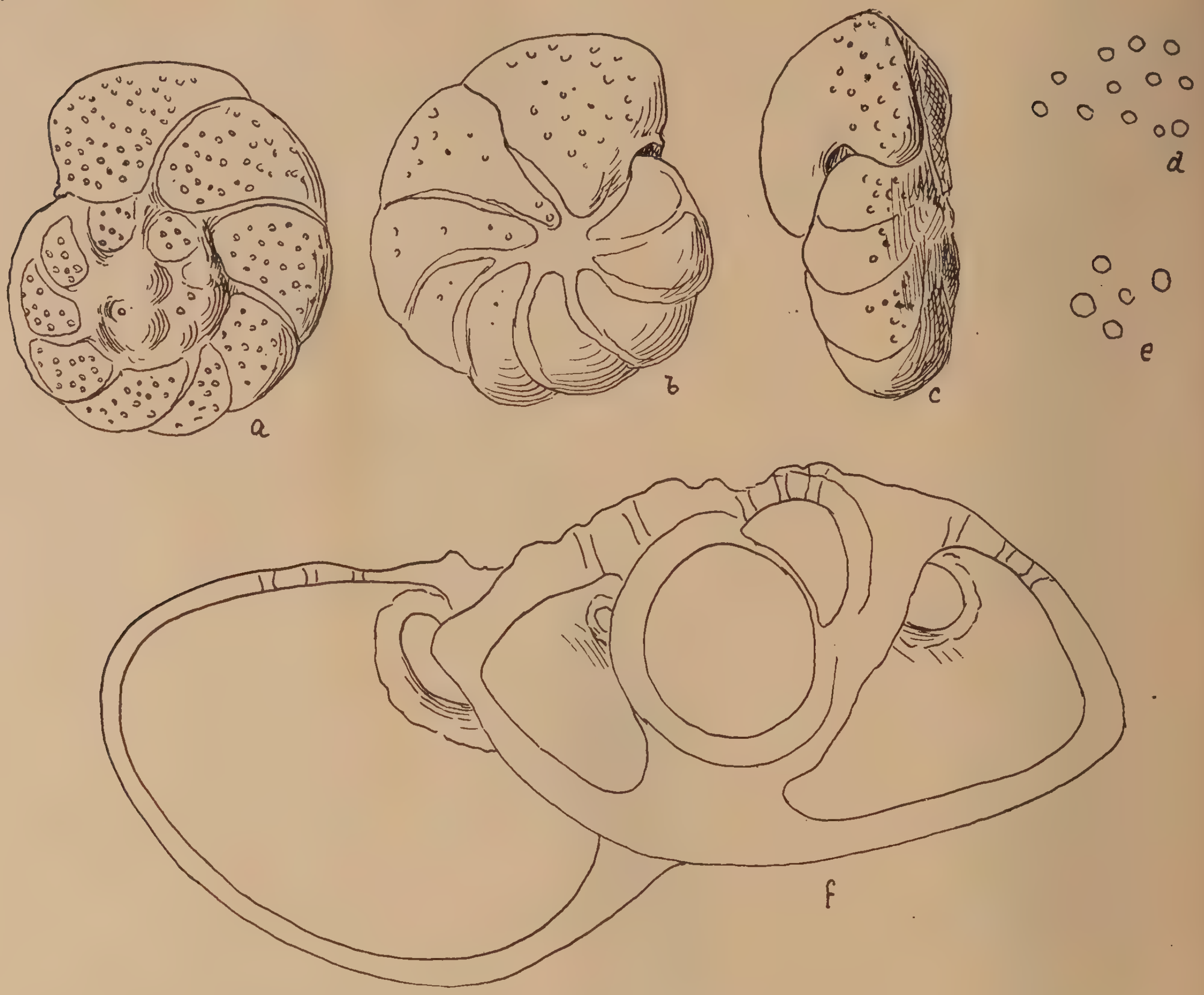


Fig. 247. *Cibicides equipunctata.* a-c, megalospheric specimen; d, ventral, e, dorsal pores; f, transverse section. a-c × 90; d-f × 435.

Cibicides (Anomalina) ammonoides (Reuss)
(Figs. 248, 249)

This species occurred in a gathering 2° 17′ S., 99° 27′ E., depth 377 fathoms, only in six megalospheric specimens. It has been found in several gatherings from the Sumatra-dredgings, but was also found in some dredgings from the Savu-Sea, off Flores. So it is found in both areas as well. Specimens, belonging to the A_2-generation, with proloculus-diameter of 62 μ, showed the typical regular arrangement of the chambers of this species. Dorsal and ventral sides are equally flattened, the chambers of the last-formed coil nearly equally equitant. But at the dorsal side the chambers of the first coils are better visible than on the ventral one, as at the latter side the forming of secundary chalk is somewhat more developed. At the dorsal side the pores are somewhat larger than at the ventral one, at the dorsal side they have a diameter of about 6-10 μ, while at the ventral side they measure only 6 μ. The difference between dorsal and ventral sides becomes at once clear, when a transverse section is made. Then all foramina show to be situated dorsally from the total surface of the apertural faces of the chambers, though they are situated nearly on the margin of them. The aperture thus is a slit, somewhat arched, and provided with a narrow but clearly distinguishable

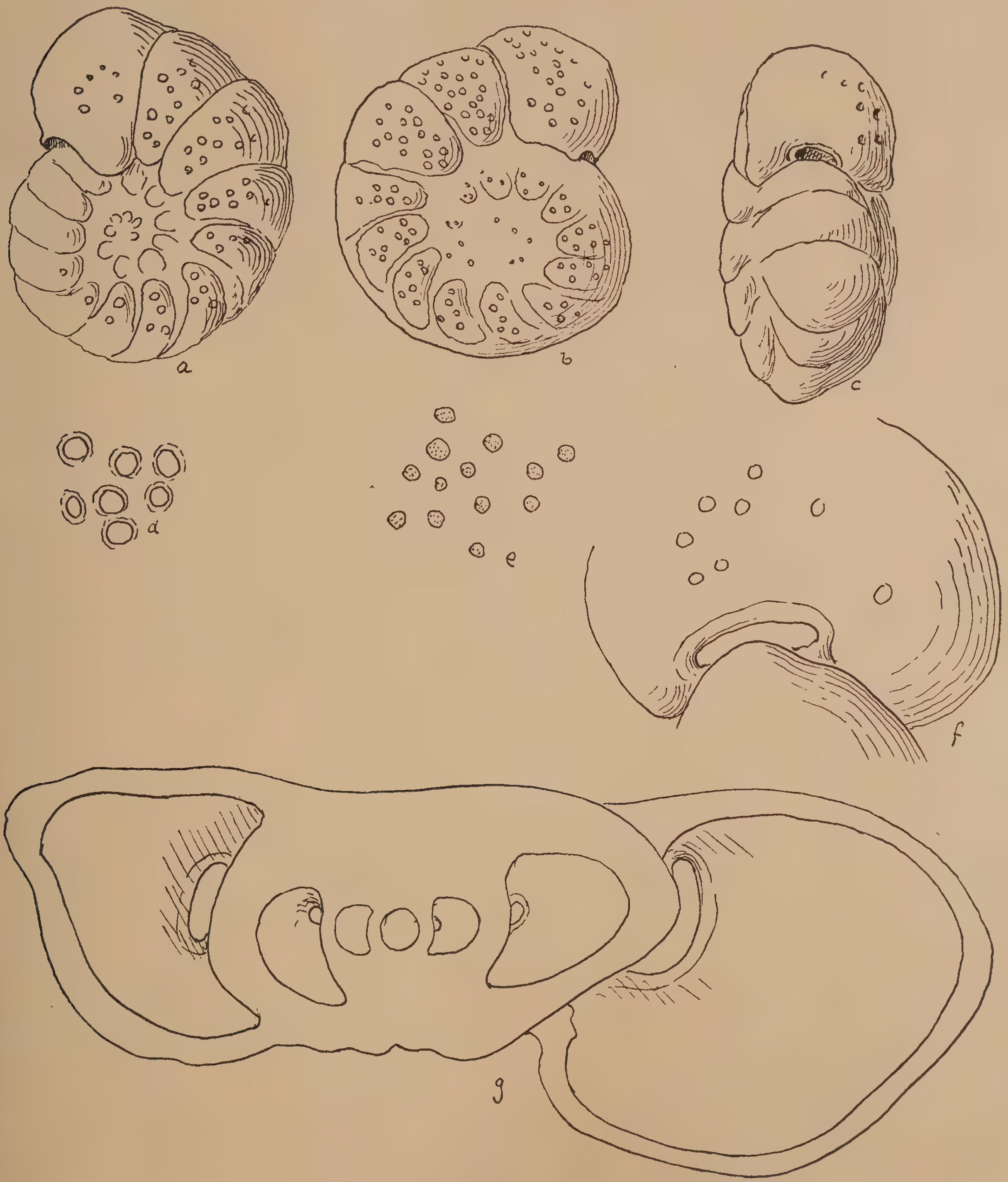


Fig. 248. *Cibicides ammonoides.* a, dorsal; b, ventral; c, side-view, × 90; d, dorsal; e, ventral pores; f, aperture; g, transverse section, dorsal side the upper side, × 435. A1-specimen.

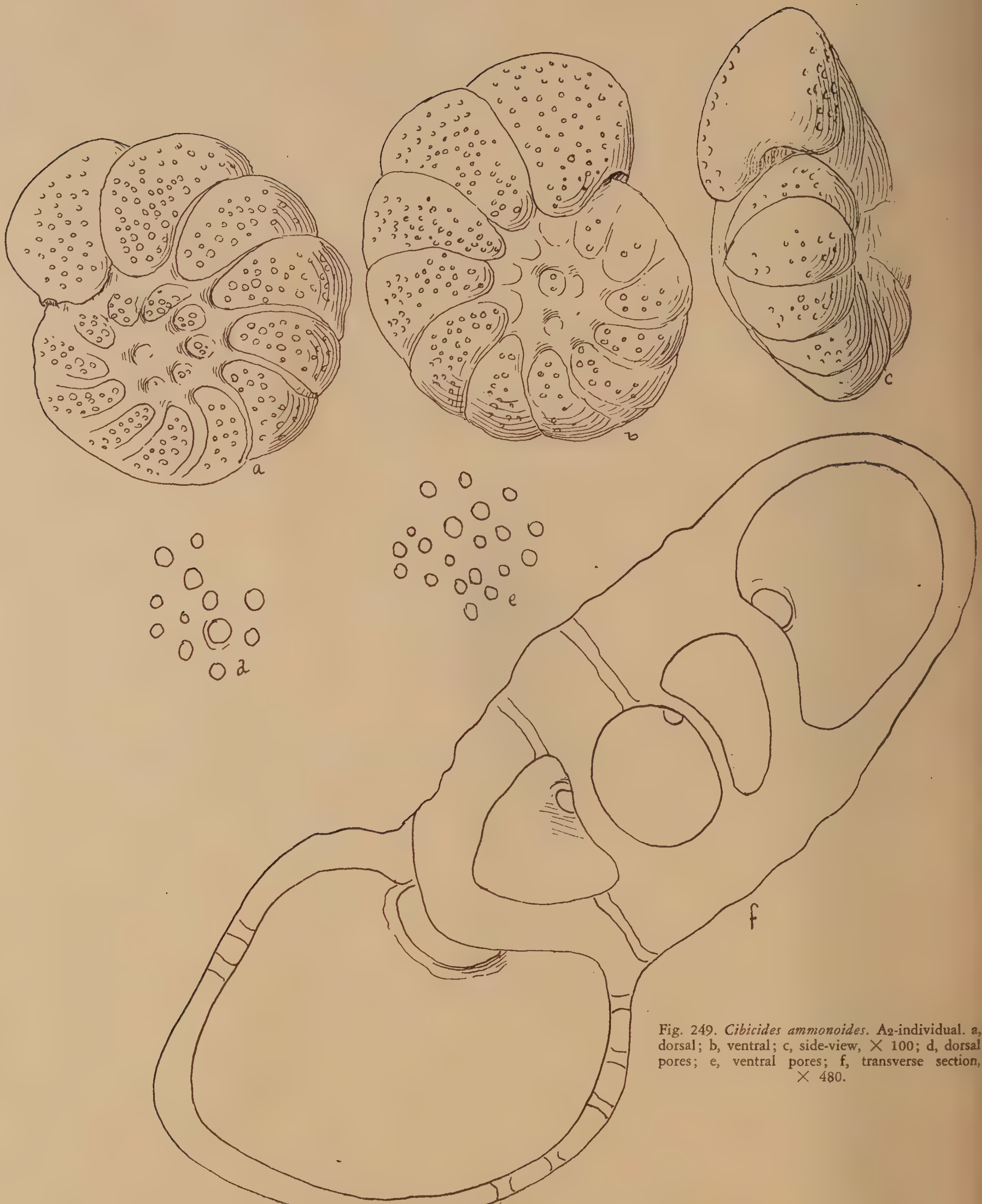


Fig. 249. *Cibicides ammonoides*. A2-individual. a, dorsal; b, ventral; c, side-view, × 100; d, dorsal pores; e, ventral pores; f, transverse section, × 480.

lip on the ventral side, and not, as is suggested by authors, marginally. Only the chambers extend somewhat towards the dorsal side of the test too, and therefore the aperture seems to be marginal.

An individual, apparently belonging to the A_1-generation, showed some other peculiarities which may be typical for that generation. At the ventral side the pores showed a diameter of 6 μ, while at the dorsal one they were much larger, and typically walled in. Most of those pores in both generations are shut by a thin wall, situated at the inner lining of the chamberwall, and provided with minute pores. This phenomenon, found too in several instances in younger chambers of other *Cibicides*-species, strongly suggests, that the coarse pores are deuteropores, formed by heaps of protopores, walled-in by the secondary thickening of the walls.

The apertural face of the A_1-individual showed some pores too, while that of the other megalospheric generation had no pores whatever. The diameter of the proloculus in the A_1 was 14 μ. Here too the difference between dorsal and ventral side was made clear by the situation of the foramina, which cannot be seen in the total individual, but is very suggestive in transverse section.

Obviously there is no real difference between typical *Cibicides,* with their course pores, their nearly or totally (in older individuals) marginal foramen, and their filling-up of the umbilicus by secundary chalk, and this *"Anomalina" ammonoides,* with its marginal or ventral foramen, its coarse pores and its umbilicus, which differs only in the very flat and wide shape of it, but which is equally filled up with secundary chalk. Only, the chambers do not extend themselves as far into the umbilical space, and they creep up somewhat towards the dorsal one. But the latter phenomenon is not constant in *„Anomalina" ammonoides,* while in typical *Cibicides,* e.g. in *C. mundula,* the chambers likewise creep up dorsally from the level of the proloculus.

Thus I am convinced, that the genus *"Anomalina"* has no right of existence, and that the whole genus has to be dropped, all species belonging, as far as they show coarse pores, to the genus *Cibicides,* and as far as they show fine pores, to other genera (e.g. *"Anomalina" baltica* to the genus *Hyalinea* nov. gen.).

Cibicides (Anomalina) flinti (Cushman)
(Fig. 250)

This species, first distinguished by Cushman (1931) from the coast of Cuba, was found in a gathering south of Sumatra in very typical specimens, all belonging to the same A_2-generation. Older specimens show at their ventral side an irregular amount of clear shell-substance in the umbilicus, younger ones do not. But all specimens show pores only at their dorsal side, thus indicating their close relationship with true *Cibicides,* in which often pores occur only at the dorsal side of the shell. At the ventral side the shell is covered with fine sandgrains, added to the chalkmaterial of the test. With lower magnification these grains may be taken for pores. Only in very old shells some scattered pores are found at the ventral side of the last-formed chambers.

The dorsal pores show a diameter of 4-6 μ. The aperture has a distinct lip and, in outgrown specimens, is found just above the margin, but in the older chambers it shows to be typically ventral to the margin of the chambers, though dorsally to the margin of the foregoing row. This is due to the fact, that, as in *"Anomalina" ammonoides,* with which the species is very much allied, the chambers are creeping up towards the dorsal side, in respect to the situation of the proloculus.

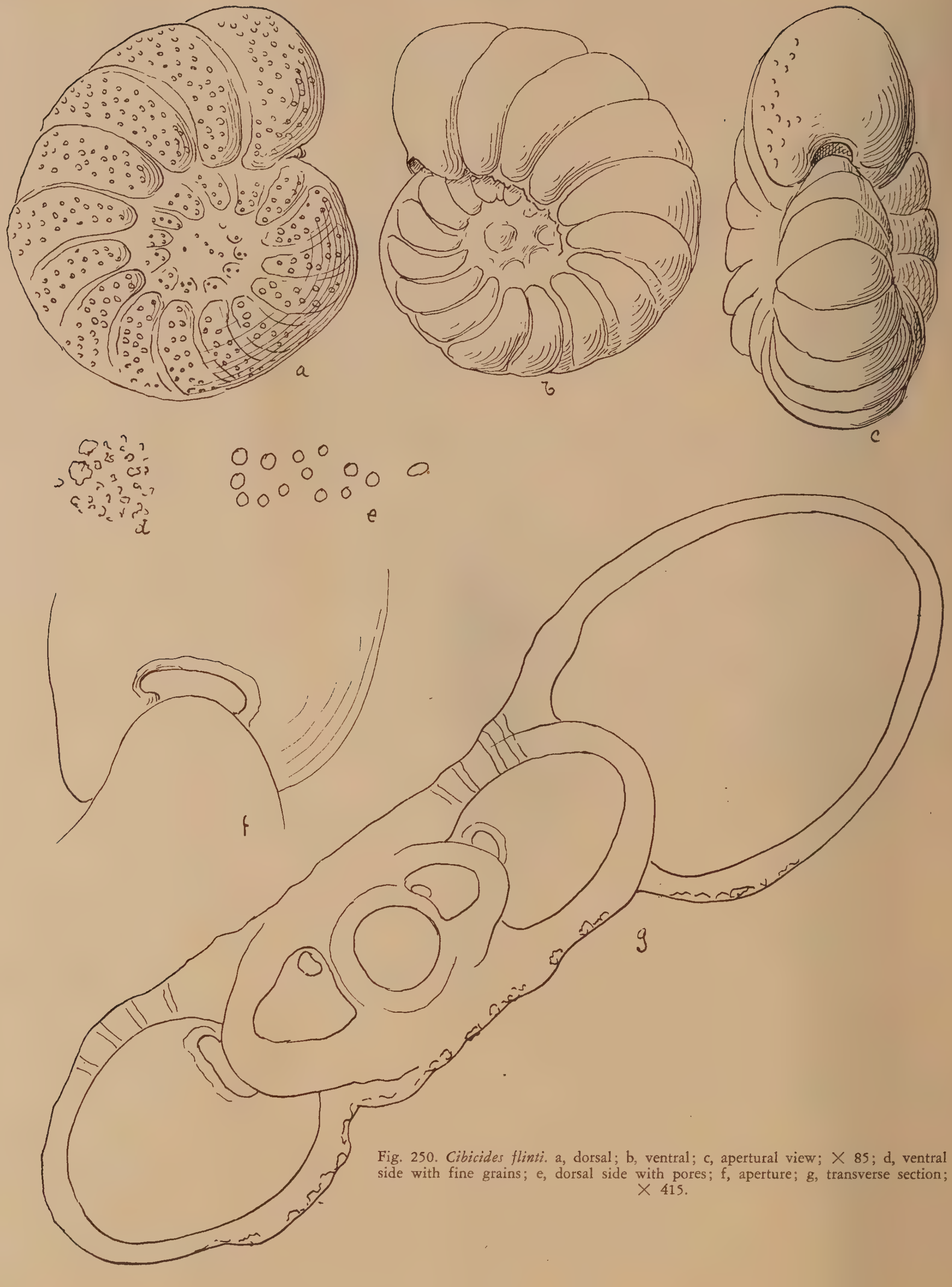


Fig. 250. *Cibicides flinti.* a, dorsal; b, ventral; c, apertural view; × 85; d, ventral side with fine grains; e, dorsal side with pores; f, aperture; g, transverse section; × 415.

Genus **Siphonina**

This genus shows, together with *Siphoninella,* the aperture at the margin, and a more or less opaque structure of the walls, together with deuteropores which, however, show a primitive character, often restricted to the sutural regions. The position of the aperture points to that, found in *Parrella* and, in respect to the protoforamen, to *Epistomina.* So it will be convincing to place these genera in the neighbourhood of *Parrella* and to consider the aperture as a protoforamen; there is, however, no trace of a toothplate. May be, that the typical neck of it is a relic of that toothplate.

Brotzen is convinced, that the genus derived from some kind of *Pulvinulinella*; I do not agree with that view, as in *Siphonina* the aperture is more like that of *Parrella* than of *Pulvinulinella.* In both genera, *Pulvinulinella* and *Parrella,* the toothplate is more or less reduced; but in *Pulvinulinella* the aperture tends to become ventral, whereas in *Parrella* it tends to become marginal. Moreover in *Pulvinulinella* the pores always are very fine protopores, whereas in some species of *Parrella* deuteropores have developed already. Both species, however, show only a protoforamen, and thus they are closely related to one another. Several characters, the opaque structure of the walls, the ventral sides without umbilicus and with overlapping chambers, the thick layers of secondary chalk at the dorsal side, point much more to *Cibicides,* and through this genus to *Parrella,* than to *Pulvinulinella.*

Siphonina reticulata (Brady)
(Fig. 251)

The name was given first by Czjek for a fossil form of the Miocene. I believe, that that fossil form, together with many others, is only a geologic (geographic) variety of the living one, and that there is only one single species living now, as well in the Pacific as in the West Indian aera. For statistic measurement came to quite the same results for both localities. As in the West Indian regions, the Pacific form, mostly found by me in gatherings south of Sumatra, and never so abundant as is the case in the Caribbean, shows in the megalospheric forms the relatively short neck of the aperture and the pores only distributed along the sutures and the carina. In the megalospheric forms this carina is clearly reticulate, whereas in the microspheric form this carina is not fimbriate while the pores, due to the thickness of the outer wall, do not reach the end of the carina. In this form the pores are not restricted to the sutures, but they are spread over the whole surface of the chambers, and are narrower than those of the megalospheric form.

These differences in the two generations have lead to very much confusion as several species, fossil and recent, are based on those differences, which are generic differences, and no specific ones. In the microspheric form the neck of the aperture is longer, and narrower than in the megalospheric form. In some localities the species is somewhat larger than in other, as is a common feature among Foraminifera, due to surrounding effects.

Thus I am sure, that the three species, erected by Cushman for living *Siphonina,* must be called by a single name. This name is *Siphonina reticulata* (Czjek), for the fossil form does in no respect differ from the recent one. *S. tubulosa* Cushman, *S. philippinensis* Cushman and *S. bradyana* Cushman are synonyms of *S. reticulata.* The species, as Cushman pointed out already, also is very much related to *S. pulchra* Cushman.

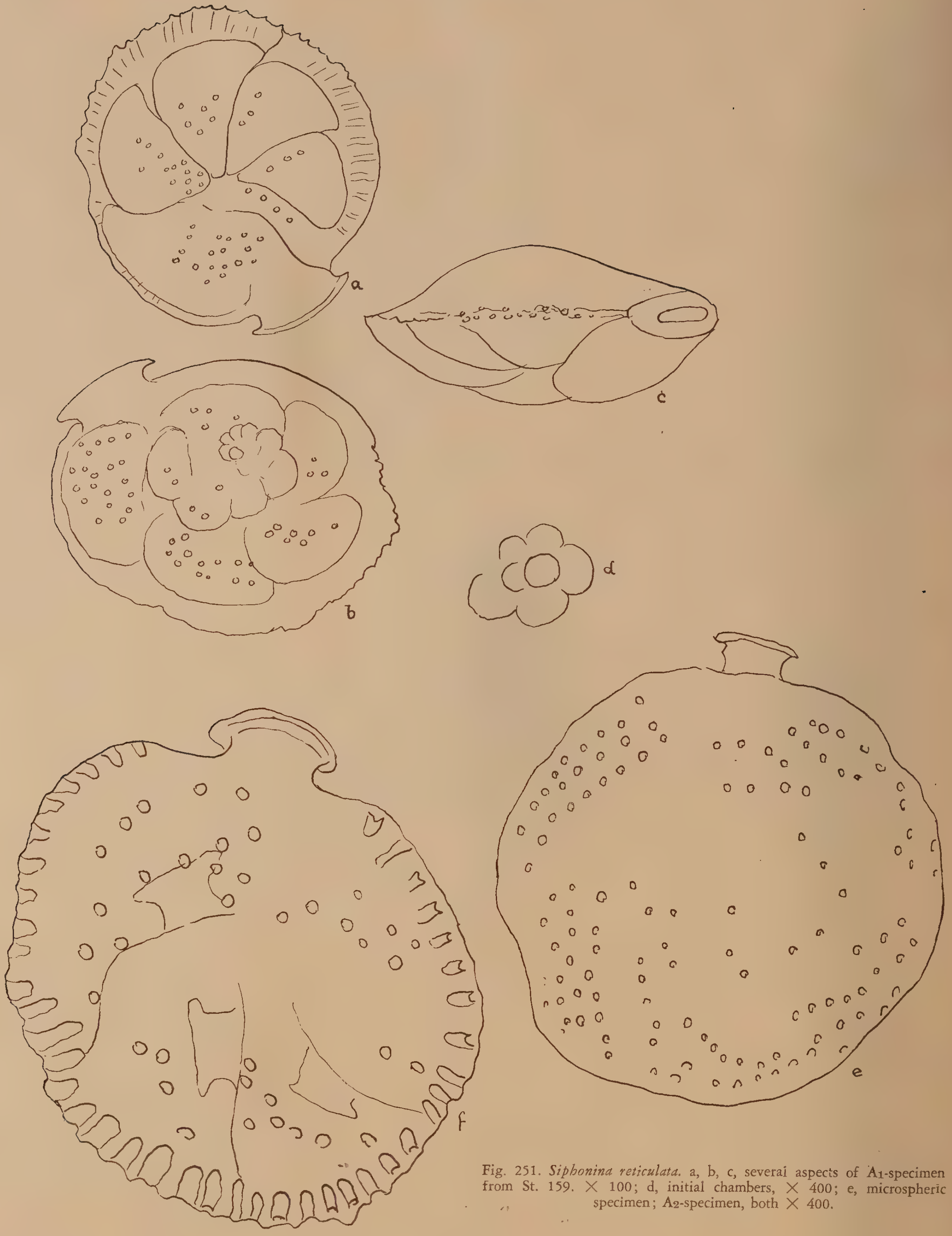


Fig. 251. *Siphonina reticulata.* a, b, c, several aspects of A_1-specimen from St. 159. × 100; d, initial chambers, × 400; e, microspheric specimen; A_2-specimen, both × 400.

S. tubulosa.	*S. phillippinensis*	*S. bradyana.*
biconvex, more convex on ventr. side.	unequally biconvex ventral side more convex.	nearly equally biconvex.
periphery acute, with distinct keel, developing into tubules.	periphery subacute, with finely fimbriate keel.	periphery with broad carina, somewhat fimbriate, tubules not reaching edge of keel.
chambers 5 in last whorl	chambers 5 in last whorl.	chambers about 5 in last whorl.
chambers slightly inflated.	ch. not inflated.	ch. not inflated.
sutures distinct, curved, slightly limbate.	s. curved, on ventral side limbate, somewhat spreading on surface.	s. distinct, limbate, not depressed.
wall with tubercules or with large perforations.	wall only slightly roughened along sutures.	wall coarsely perforate, smooth.
aperture broadly elliptical, with distinct contracted neck and lip.	a. elongate elliptical without a neck (A_2!).	elliptical with broad flaring lip but very short neck.
Indopacific.	Philippines.	West Indies.

As I pointed out already, that the thickness of the shell, the more or less inflated chambers on the ventral side, the thickness of the walls, the distribution of the pores on the walls as well as on the carina, the shortness of the neck, the fimbriation of the carina, all those characteristics are variable along the line of generation, it will be obvious, that those three species cannot be separated on those characteristics, and must be regarded as a single species, moreover, as the statistic study of them shows no differences at all.

The species was found only in scattered specimens at the stations St. 159, 0° 59′ S., 129° 48′ E., depth 411 m. 2° 26′ S., 100° 0′ E., depth 222 fathoms.

I haven given a detailed study on the species in my work on the West Indian Foraminifera.

Family *Epistominidae*

In this family I have placed only the genus *Epistomina.* In case, that it would prove to be true, that the genus *Epistomina* Terquem (with genotype *E. regularis* Terquem) shows quite other characters than the Jurassic *Epistominae* I studied, the genus *Höglundina* Brotzen would be enclosed in this family. It may be too, that further investigation about the inner structure would reveal differences between those forms, in which the toothplate is maintained in all chambers, and those which absorb these toothplates in older chambers. In that case a third genus would be necessary.

The family as such shows two kinds of foramina, protoforamina and deuteroforamina, the latter being placed marginally. The toothplate always shows a plate, running slightly obliquely from the septal foramen (the deuteroforamen) towards the protoforamen. The walls are always opaque, smooth and shining, or ornamented by heavy ridges (Lower Cretaceous) at the sutures and at the protoforamen. Walls always brownish. Fine protopores.

The genus *Epistomina* is found upwards from the Dogger at least.

Genus **Epistomina**

This genus has been analysed by Brotzen (Sver. Geol. Unders., Ser. C., o. 493, 1948, p. 92-94). In this analysis he distinguishes between two genera, closely allied, the one with the genotype

Rotalia elegans d'Orbigny which he calls *Höglundina,* the other with the genotype *Epistomina regularis* Terquem which he has named *Epistomina.*

Now, there are several objections to make against these views of Brotzen's; in the first place Terquem's descriptions and figures are always very superficial and often are lacking details in such a way, that it is very difficult to trace a species to the species, he has described. So it is with his species *E. regularis* too. In the second place there seems to be in the species, Terquem described as *E. regularis* only a single aperture, situated near to the margin, and areal. This single aperture, when really observed rightly, at once points to the fact, that this species *E. regularis* cannot at all be classified with *Epistomina elegans,* as in that case it possesses only a protoforamen, and thus belongs to the *Biforaminata protoforaminata,* and consequently is quite a different genus, having nothing whatever to do with *Epistomina.* And in the third place, when the observation of Terquem is a right one, it may be too, that his species does not even belong to the *Biforaminata,* but to the Terquem, as it is in the Jurassic species *E. stelligera* a short and inconspicuous opening. Yet the *Deuteroforaminata,* allied to *Conorbis.* May be, that the protoforamen has been overlooked by toothplate reveals it undoubtedly. All these objections give to me the feeling, that the new species *Höglundina* has been created somewhat premature, as we know nothing about the inner structure of Terquem's species. As, on the other hand, the species *elegans* is now fully known, and moreover it has been shown, that many cretaceous species show typical homologies with the species *elegans,* and that no real *Epistomina*-species with a single foramen is structurally studied yet, I believe it better to give here the usually used name, *Epistomina.*

In fossil species of *Epistomina* the protoforamen is already situated marginally, though it is here often much shorter than in more recent species. In some of these species the toothplate is maintained in all chambers, following the proloculus, e.g. in the species *E. stelligera* from the Jurassic; there are, however, other species from the Gault which show already the absorption of the toothplate in older chambers; in recent species it always is absorbed. This absorption leads to the conclusion, that the toothplate has a function, which is in some respect in connection with the protoplasm contained in the last formed chamber. This function may be one of attachment.

The genus always shows closely coiled tests, with a more flattened dorsal side, and a ventral side, always showing overlapping chambers, reaching the centre of the ventral side. The toothplate always is attached to the dorsal (marginal, proximal) border of the protoforamen, whereas the deuteroforamen always is situated near to the ventral suture of the chamber. The plate runs over the protoforamen, then makes at its distal end a curve around its shorter side, and then runs downward; after a short run the attached part ends, and a free folded part is formed which, in some species of the Lower Cretaceous, as well as in a recent species from the West Indian region, shows a complication in the forming of a ventral toothlike outgrowth.

The texture of the tests always is an opaque one, with yellowish or brownish colour. The pores are always very fine protopores, and in some species, especially in *Epistomina elegans,* are grouped together as to form a meandering ornamentation.

Epistomina stelligera Uhlig

(Figs. 252, 253)

This species occurred in several not very well preserved specimens in the boring R from the Rijksopsporing van Delfstoffen (Veldzicht) at a depth of 70 m. This stratum is typical Dogger.

I was able to make several good sections which reveal all characteristics of the species. The test is flattened at the dorsal side which is only slightly convex with a large amount of secondary chalk at the centre. The ventral side is much more convex, and the chambers here are distinctly inflated, the sutures between depressed. They leave a large umbilical region free, which likewise is filled up with secondary chalk. The septal foramen is situated at the dorsal part of the suture, but always ventrally to the toothplate which begins at its dorsal border. This toothplate is very simple, a nearly horizontal plate, with a slightly curved foreside with a very narrow free folded part. It is attached dorsally from the protoforamen, which in this species is not parallel to the margin, but curved, beginning about the middle of the ventral suture, then running toward the margin, and then abruptly

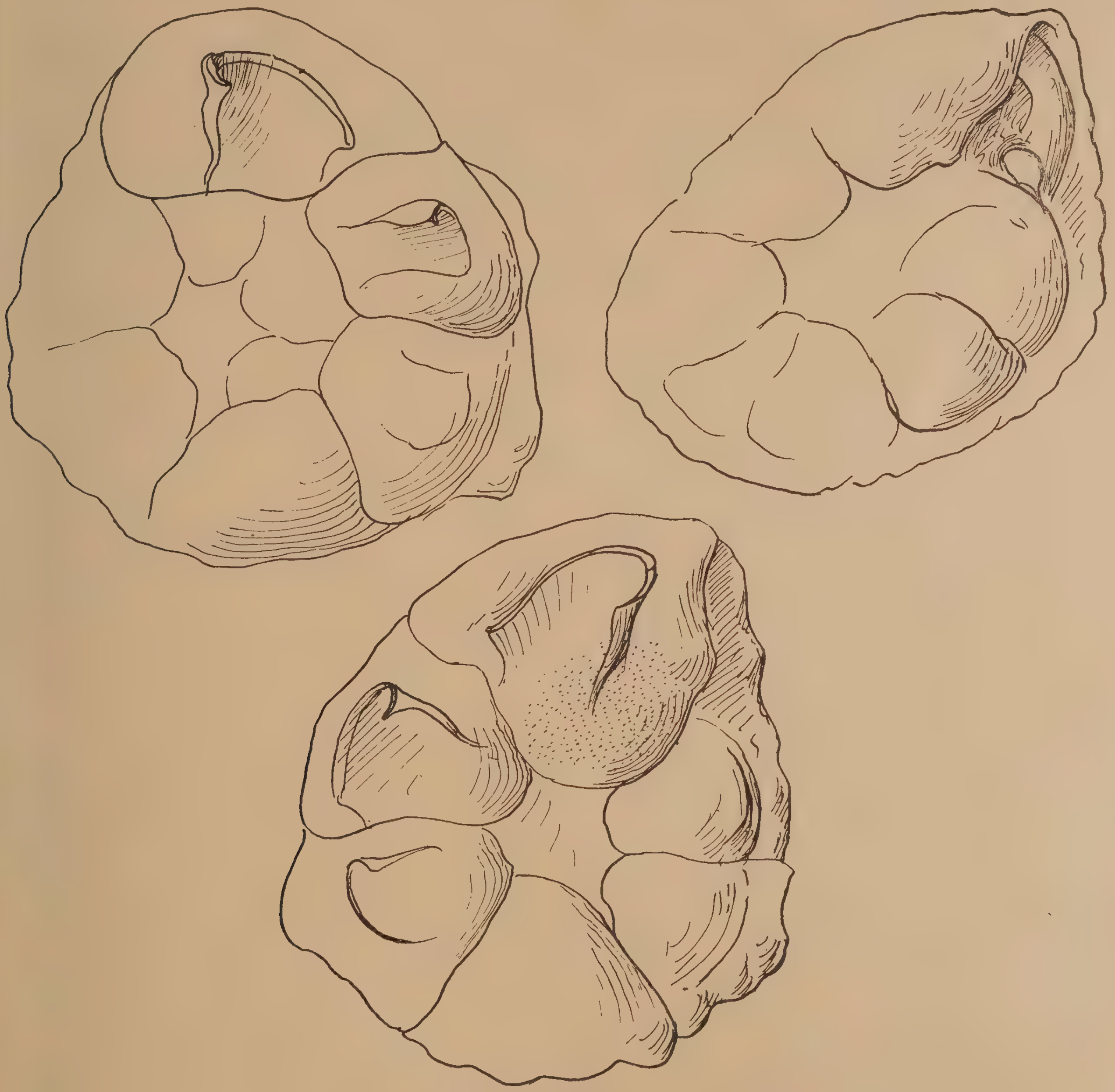


Fig. 252. *Epistomina stelligera* from the Dogger of the Netherlands; views from the ventral side, showing deuteroforamen, protoforamina with the toothplates in optical section. × 480.

ending, whereas the toothplate forms a curved suture before the end of the protoforamen. This suture is the fastened part of the free folded part of the toothplate. The plate is very thin and quite hyaline, and is nearly fan-shaped, without the large folded part of modern *Epistomina.* It holds the midst between the toothplate of several Albian *Epistominae,* I studied. Contrary to the *elegans*-group, this toothplate is not absorbed in older tests, but remains, so that in older tests the chambers

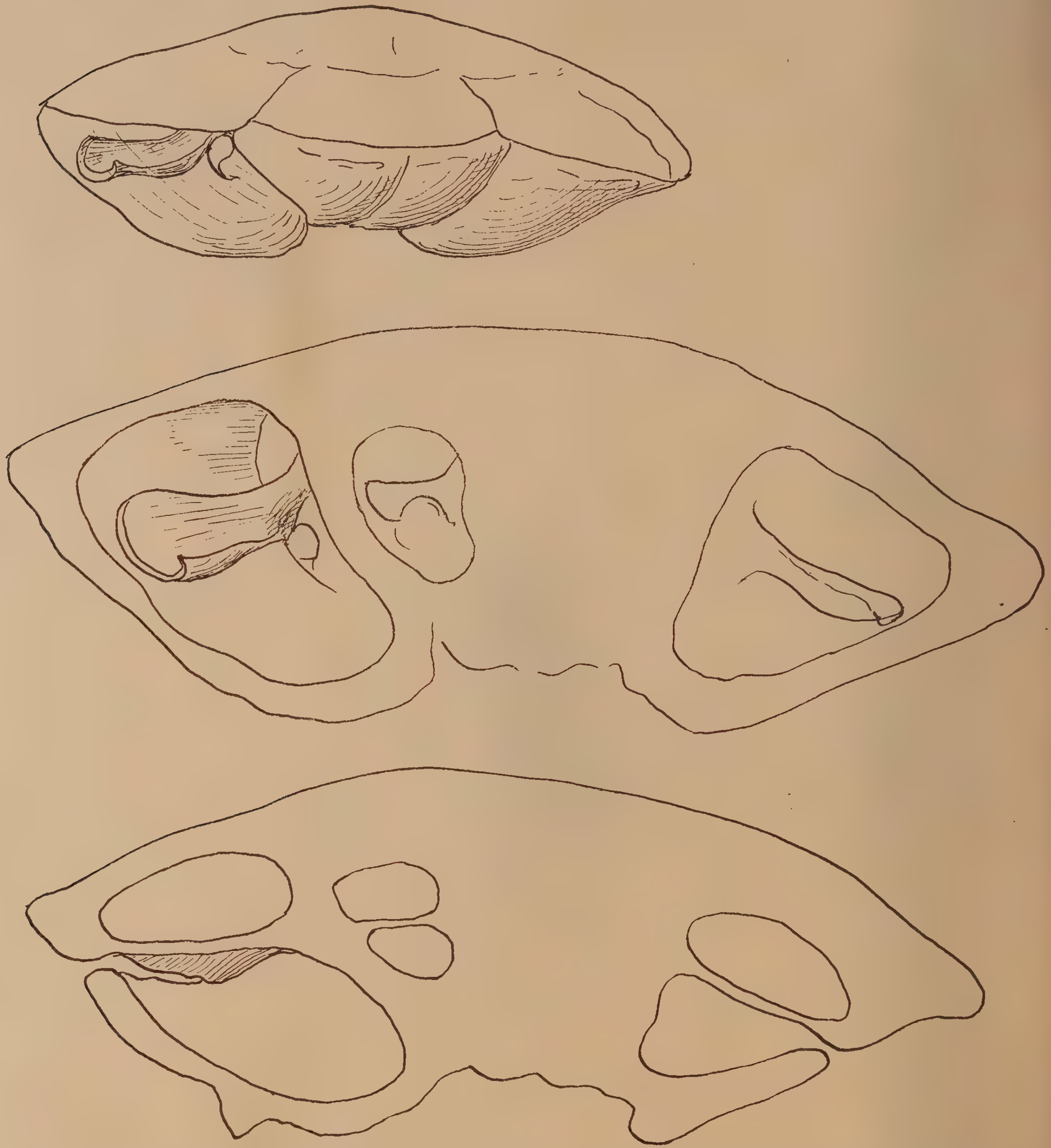


Fig. 253. *Epistomina stelligera* from the Dogger of the Netherlands. a, sideview, showing deuteroforamen and the toothplate of the last-formed chamber in optical section; b, section, not through the centre, showing situation of toothplates; c, radial section. Both × 630. The central parts disappeared due to fossilisation; a × 480.

of all whorls are seen devided in an upper, smaller, and a larger lower part. In this way the total aspect of a chamber resembles that of *Asterigerina,* in which likewise the toothplate runs nearly horizontally. But the open protoforamen shows easily the difference between both sections.

This *Epistomina* from the Jurassic clearly points to the fact, that in more primitive *Epistomina* the toothplate is not resorbed in older chambers. I found this phenomenon likewise in the tests of an ornamented species from the Albian. But in those forms which resemble *E. elegans,* the toothplate is resorbed. In those species the toothplate becomes more complicated in the later species, as protuberances and teeth, even large flanges occur in modern species. Here we have a Jurassic species from the Dogger which would according to Brotzen, belong to the genus *Epistomina* with single aperture. The figures, given here, clearly show, however, that the deuteroforamen exists, situated at the suture, though more to the margin than is the case in recent species.

Epistomina is without doubt an old genus of the *Biforaminata.* As *Epistomina* occurs together with *Reinholdella* Brotzen in the Dogger, and as both genera show in this stratum a primitive toothplate, together with primitive characters, it is a matter of taste, whether *Epistomina* or *Reinholdella* is the older genus. It will be clear that both genera, with very fine pores, opaque yellowish-brown structure of the walls, and a coiled spire of well-developed chambers, must have derived from an ancestral form, which showed already a coiled spire of chambers, a more or less chitinous wall, and toothplates in each chamber. For the toothplate occurs in both genera in a well developed, though primitive condition. It is a remarkable fact, that both genera show already two kinds of foramina. This cannot be a primitive condition. So they must have derived from a protoforaminate species, may be a *Lamarckina.*

Epistomina elegans (d'Orbigny)
(Figs. 254-257)

This species has been described under this name from recent and fossil localities over the world. Its most characteristic feature seems to be in these descriptions, that the very fine pores are arranged in groups, irregular of shape, and forming a moiré pattern. I have observed such typical specimens from the Albian, the Tertiary, together with recent material from the Pacific as well as from the West Indian region. And yet it was found by closer examination, that these specimens do not belong to a single species, as in several localities the shape of the toothplate is highly differing. It is true, all those species belong more or less together, with those forms which are characterised by costate sutures, known from Jurassic and Cretaceous. Their outer features are very similar, and only the size of tests, together with a more or less convexity of the dorsal side, can be taken as different in those different localities. But these characteristics can only be studied and used as distinguishing features, when larger material is available, so that statistic study can be made. The toothplates however are always typical in each of the species which are found in different recent and fossil localities and which till now are thrown together as *Epistomina elegans,* and are characteristic for each species as well. So, when describing species of this remarkable genus, we have to study the toothplate as the only reliable characteristic.

I here shall deal only with those forms, hitherto gathered under the name of *Epistomina elegans.* They all show the resorption of the toothplate in older chambers. Their toothplate in principle runs from the septal foramen of the lastformed chamber with its folded back slightly curved up to the oral end of the marginal aperture. It forms with its attached part the dorsal border of this aperture. This attached part runs along the whole dorsal border of the marginal aperture, and then runs along the septal wall of the chamber to the ventral and proximal border of the septal foramen. The free folded part forms, as is said already, the oral border of the marginal aperture, and afterwards, in the Albian species, runs back proximally along the lower border of the short oblong aperture, enclosing it totally. Thus in this species it forms a kind of tube at the marginal aperture which is covered at its walls by blunt pustules. Soon however this tube opens its oral side and the free part becomes visible, forming a short protruding building, running up to before the aperture of the chamber at its ventral base.

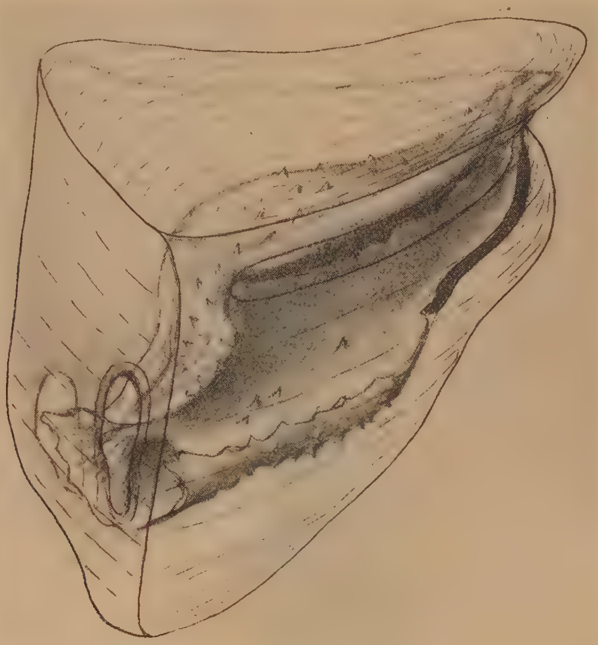


Fig. 254. *Epistomina elegans*. Total last formed chamber, seen from marginal side; the former aperture is seen in the septal wall, the aperture of the chamber can be traced at the backside; the toothplate originates from the septal foramen, runs toward the marginal aperture, its free part attached at the ventral side of it, distally.

In species, found in the Tertiary of Holland, I found toothplates which resemble that, described from the Albian species, but they are more highly developed, and the attachment of the free folded part at the ventral border of the marginal aperture distanciates itself from it, forming a short suture with the outer wall, and an angle with the direction of the marginal aperture. This status reaches its highest development in the recent species, as the free folded part here develops into a highly organised plate ventrally from the main toothplate, in one species in the West Indian region developing into remarkable protuberances and secondary tubes, whereas in the Pacific species the toothplate is of a more simple type, though much higher developed than that, found in the Albian species.

I shall describe more fully the toothplate of the recent Pacific species. As I pointed out already, this toothplate is only found in the last formed chamber; in all former chambers it has been resorbed but for some ridges at the places, where it was attached to the outer or septal walls.

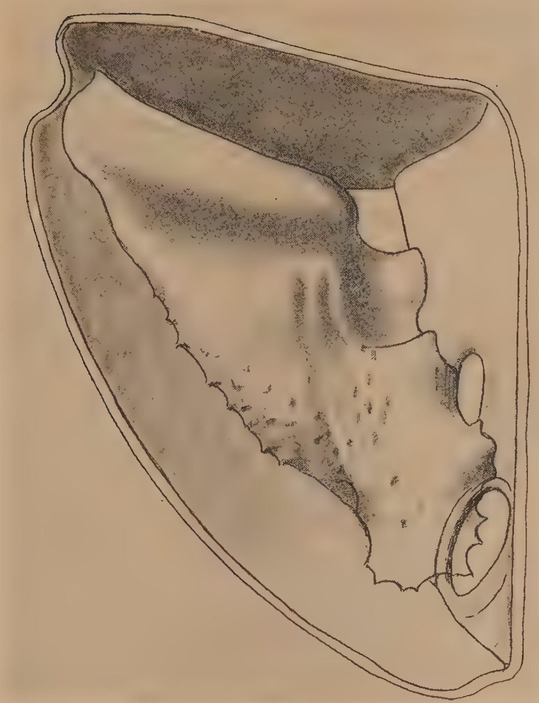


Fig. 255. *Epistomina elegans.* Last formed chamber, seen from oral side; the toothplate forms a special outgrowing peeping through the opening of the aperture below. The former aperture can be seen at the septal wall. The marginal aperture is totally covered by the dorsally attached toothplate. Glassplate drawing.

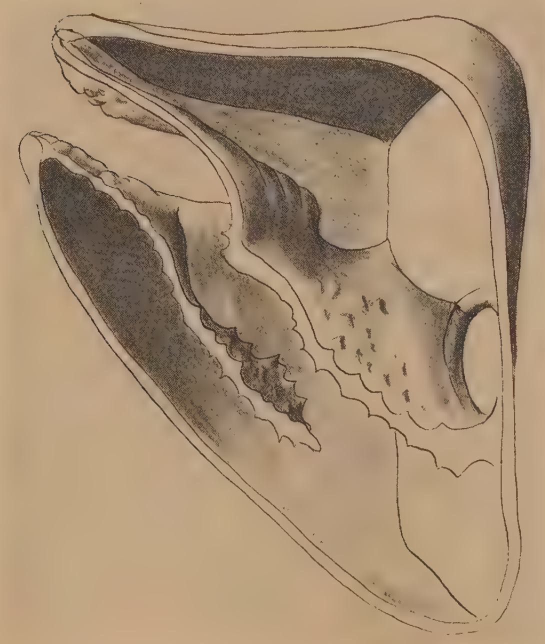


Fig. 256. *Epistomina elegans.* Last formed chamber ground down at about the middle, showing the toothplate, originating from septal foramen, running up to dorsal border of marginal aperture; free part of it attached partially to ventral border of it. Glassplate drawing.

The toothplate originates at the ventral and proximal wall of the septal foramen; its attached part runs proximally along the septal wall up to the outer wall of the chamber, and forms then a short suture with this outer wall, running to the dorsal border of the marginal aperture. Here it forms the dorsal border of this aperture, covered at the inside with fine and sharp spinous protuberances. It runs along the whole side of the aperture, and forms also the short oral border of it. Then the folded part of the toothplate runs down ventrally, forming a relatively short suture which begins at the oral border of the marginal aperture, and forms an angle with this aperture of about 45°. With a rounded folding the plate now becomes free, forming a broad and flaring free part which on both sides is covered with sharp spinous tubercules, mostly directed towards the marginal aperture. It forms not only a flaring plate directed backwards, but at its septal side it bends towards the ventral aperture, so that one sees this dentated part when looking through the aperture. The toothplate is much thinner than that, found in the Albian species.

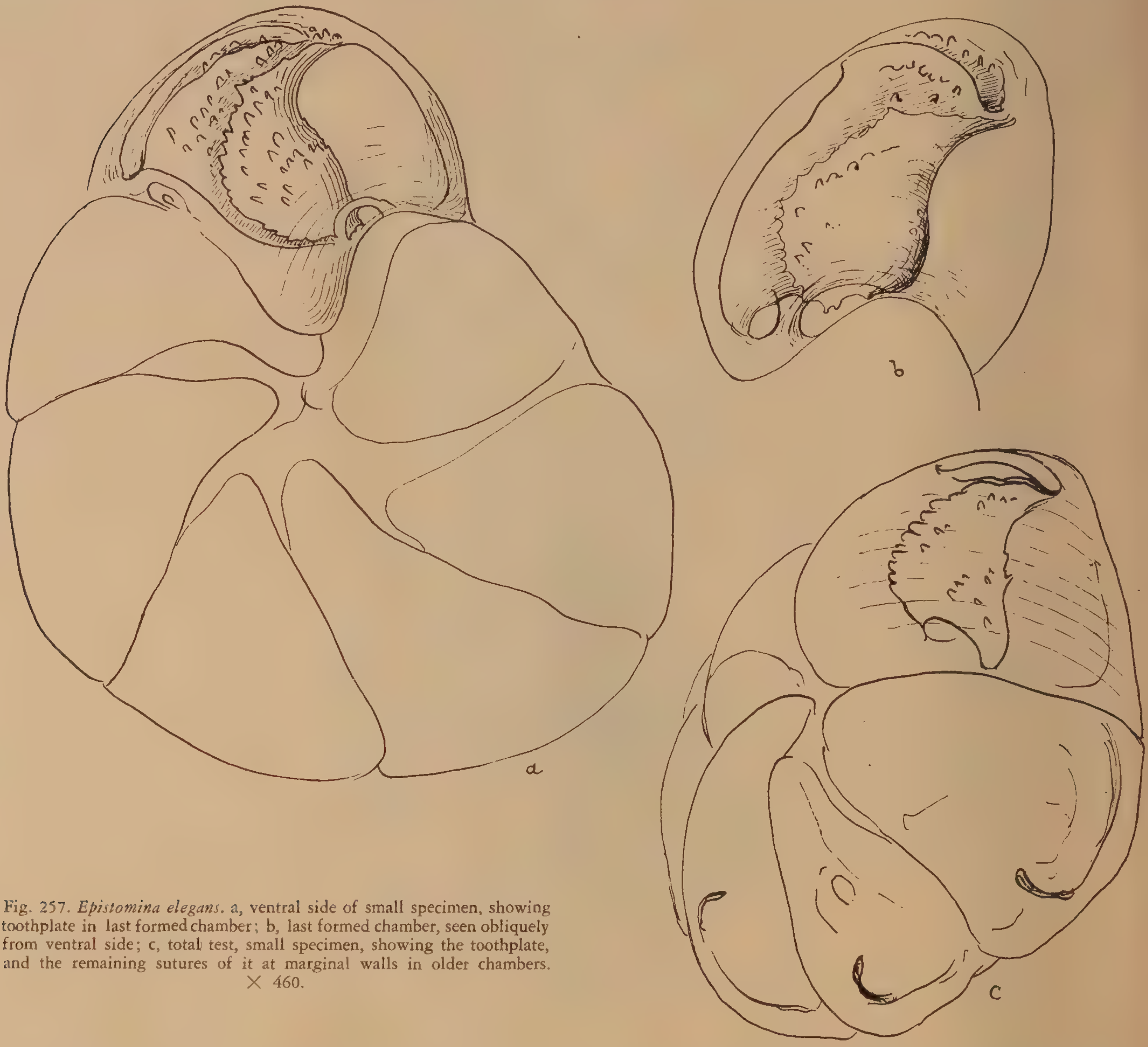


Fig. 257. *Epistomina elegans.* a, ventral side of small specimen, showing toothplate in last formed chamber; b, last formed chamber, seen obliquely from ventral side; c, total test, small specimen, showing the toothplate, and the remaining sutures of it at marginal walls in older chambers. × 460.

As this Pacific species differs from the two species, found in the West Indian region, as well as from the several species, known from fossil localities, in respect to its toothplate, and as this toothplate always is a contant characteristic, I am convinced, that it forms a distinguishable species which may be called *Epistomina pacifica* nov. spec.

The other species, mentioned here, will be described in another paper.

Statistical investigation proves, that the species shows no typical trimorphism. All specimens gathered were probably megalospheric; the total number of chambers was from 6 to 22, the larger specimens showing the larger number of chambers. The proloculus ranged from 25-120 μ diameter.

The species is widely spread all over the Archipelago, mostly found in deeper water, especially in Globigerine-oozes.

Family *Robertinidae*

This family includes the genera *Robertinoides, Robertina, Pseudobulimina* and *Cushmanella.*

They all show very thin walls, a coiling with high pitch in *Robertinoides* and *Robertina,* with less pitch (and with contorted chambers) in *Pseudobulimina,* and a planispiral coiling in *Cushmanella.*

The toothplates belong to the most complicated forms known. They always show the tendency to form canals in the attached part, by folding this part. These canals may be single (*Robertinoides, Robertina, Pseudobulimina*) or double (*Cushmanella*). They always end in a porus, called supplementary aperture, closed in older chambers by a porous plate or remaining open (*Cushmanella*). The pores are always very fine protopores. In *Robertina* the protoforamen is closed, as is the case in *Pseudobulimina.* In some recent forms of *Cushmanella* likewise the protoforamen seems to be closed, or closing.

Most of these species seem to be pelagic ones.

Genus **Robertinoides**

This genus has been fully analysed by Höglund (Zool. Bidrag Uppsala, Vol. 26, 1947, p. 222). It belongs, according to my investigations, to the *Biforaminata,* and it can be described as follows.

Test elongate, coiled in a spiral with high pitch, somewhat resembling that of *Buliminella.* About three chambers form a whorl. The chambers are strongly overlapping backwardly with a chamberpart, separated from the main chamber by the toothplate. This recurrent chamberpart can be homologized with the chamberpart, found in *Epistomina* between the fastened toothplate part and the protoforamen in that genus. The protoforamen in *Robertinoides* is a narrow slit found just underneath the toothplate, when the test is placed in the same direction, as it is usually placed in *Epistomina,* proloculus upward. Attached part of toothplate with peculiar canal, running from protoforamen toward a supplementary foramen at the backside of the chamber. Toothplate a flat plate, with a curved free folded part, running over and toward the deuteroforamen, which is the main foramen of the larger chamberpart below. Wall always very thin, with very fine protopores. Pelagic?

When described in the above mentioned manner, the genus seems to have derived straightly from *Epistomina* and not from *Ceratobulimina.*

The closely allied genus *Robertina* seems to have derived from *Robertinoides*, by closing the protoforamen or the reserved development may have taken place.

Robertinoides oceanica (Cushman et Parker)
(Figs. 258-264)

This species of *Robertinoides* has been described as new by Cushman et Parker (U. States Geol. Survey, Prof. paper 210-D, p. 75-76, pl. 18, fig. 18). The definition runs:

"Test slightly longer than broad, very broadly fusiform, initial end subacute to rounded, apertural end broadly rounded; chambers distinct, much inflated, 3 to 4 pairs in the adult whorl, increasing very rapidly in size as added; wall smooth, polished; aperture elongate, distinctly curved, narrow; secondary aperture very distinct, about half as long as the primary. Length 0,70 to 0,80 mm, breadth 0,55 to 0,60 mm."

As Cushman mentions the Challenger-stations Kai Islands and New-Zealand, this may be the species described here. The figure does in some respects, e.g. the distance between normal and second aperture, agree with our species.

The toothplate shows in total the typical structure, found by Höglund (1947). But in some respects it is different; this difference may be caused by the unsatisfying method, used by Höglund, perhaps in his species the structure differs from that, found in the Pacific species. I have used quite a different method as that of Höglund, as I found, that when loosening a chamber from the test, often parts of walls of former chambers remain attached to it, so that the real shape of the toothplate cannot be followed with certainty. I enclosed the specimens in Canadabalsam and, after heating it sufficiently, I made one or two grinding strokes on a very fine limestone. The result of the grinding was drawn; then a second stroke was done, and a second drawing made, and so on, till a whole chamber was ground down. In all drawings the outline of the whole test was drawn too, so as to make it possible to orientate the different drawings which were copied on glassplates; these glassplates were placed one after an other, and so a very good and clear idea could be obtained of the plate in total, as well as in parts. Thus the drawings, given here, were made. The orientation of the test was done likewise as it was by Höglund, but the main chamber was orientated upright down.

Description of the toothplate.

This plate originates from the former main aperture, accurately from its distal border. It forms a flaring part, attached to the wall of the chamber along the suture between the main and the additional chamber, and this flaring part at its attached border is folded into a narrow tube, running from a narrow foramen at the backside of the chamber toward the second foramen at the apertural side, gradually widening toward this second foramen. This attached flaring part forms moreover a slightly folded very thin plate, the septum between the two chamberparts. This septum is, as is said already, attached along the suture between the two chamberparts, and only leaves an opening free at the suture at the apertural side, just behind the second foramen.

From this attached part the folded free part originates, which part folds down behind the main aperture and shows a free border just at the space between the former and the new aperture. At the opposite side of this free folding part a large, more or less triangular window is found, giving access from the main aperture into the main chamber which, moreover, can be reached from the aperture too by the narrow slit between the free folded part border and the basal chamberwall. In the hollow, formed by the free folding part a blind sac is opening, which sac here is relatively large, and is closed at the outer apertural side by the part of the chamberwall between the main and the second apertures. The only connection between the tube and the hollow of the folded part is found behind the wallet, separating the main aperture from the second one, just above (in our orientation of the test) the blind sac.

The whole structure shows, that it can easily be compared with the toothplates, found in higher organised *Buliminae,* together with those, found in *Ceratobulimina* and *Epistomina.* The difference with real *Bulimina* lies especially in the fact, that in *Bulimina* the tube in the attached part of the plate opens at its backside into the lumen of the chamber, whereas here it opens at the backside of the chamber into the outer world. This deplacement is obviously due to the extension of the attached part, running nearly totally along the outer wall. This extension causes the separation of the chamber in two parts.

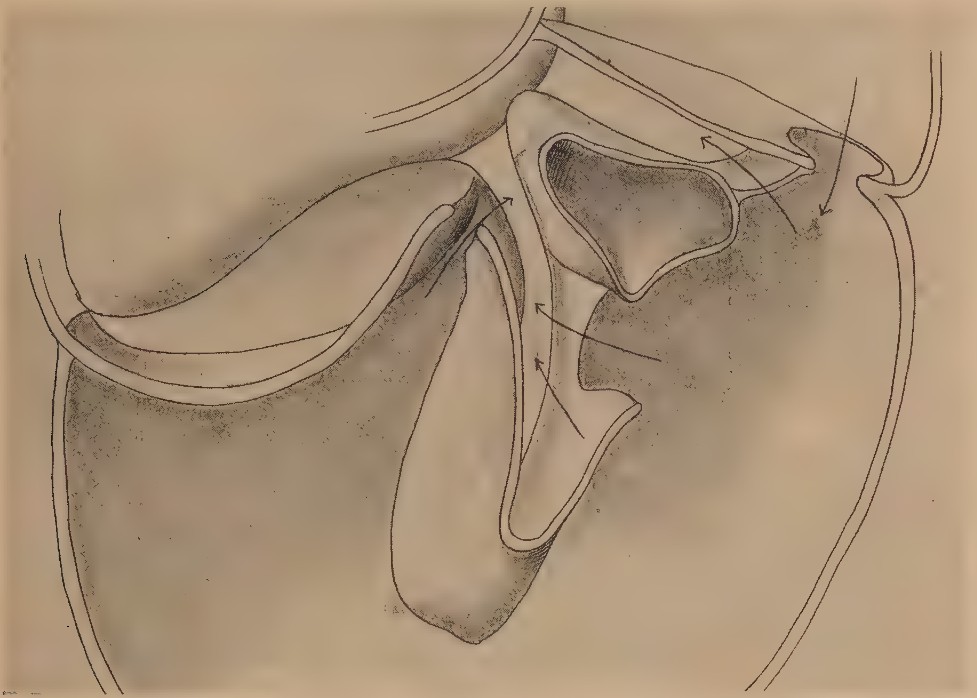


Fig. 258. *Robertinoides oceanica.* Section through last-formed chamber very much near the aperture, demonstrating the toothplate with slit at free part, the sacculus, the opening of canal into second foramen, and the slit betweeen chamber and accessorial one. Drawing from glassplates.

In the orientation given here, the second foramen is found at the side of the normal aperture which is directed towards the initial part. In *Epistomina* likewise the second aperture is found at the initial side of the chamber. As in both cases this second aperture is connected with (and obviously formed by) the folded tube of the attached part of the toothplate, it is obvious, that these two apertures are homologous. I found, however, that the marginal aperture of *Epistomina* is the protoforamen; thus the so-called second aperture of *Robertinoides* in reality is a protoforamen, which can be homologized with that of *Buliminella.*

The individuals, found in gatherings south of Sumatra (2° 26′ S., 99° 35′ E, 582 fathoms, and 2° 17′ S., 99° 56′ E., 613 fathoms), differ only slightly from those, found in the Danish West

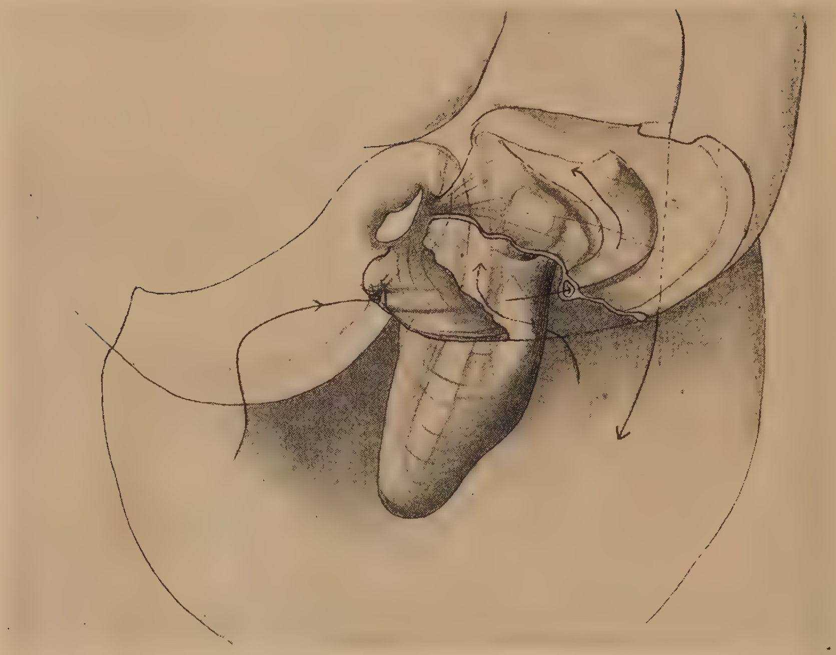


Fig. 259. *Robertinoides oceanica.* Last formed chamber, seen from behind. The horizontal plate of the toothplate is partially removed, demonstrating the canal from dorsal foramen the foramen to former chamber to second one, the slit between chamber and accessorial one, and the attachment of toothplate to its border. Drawing from glassplates.

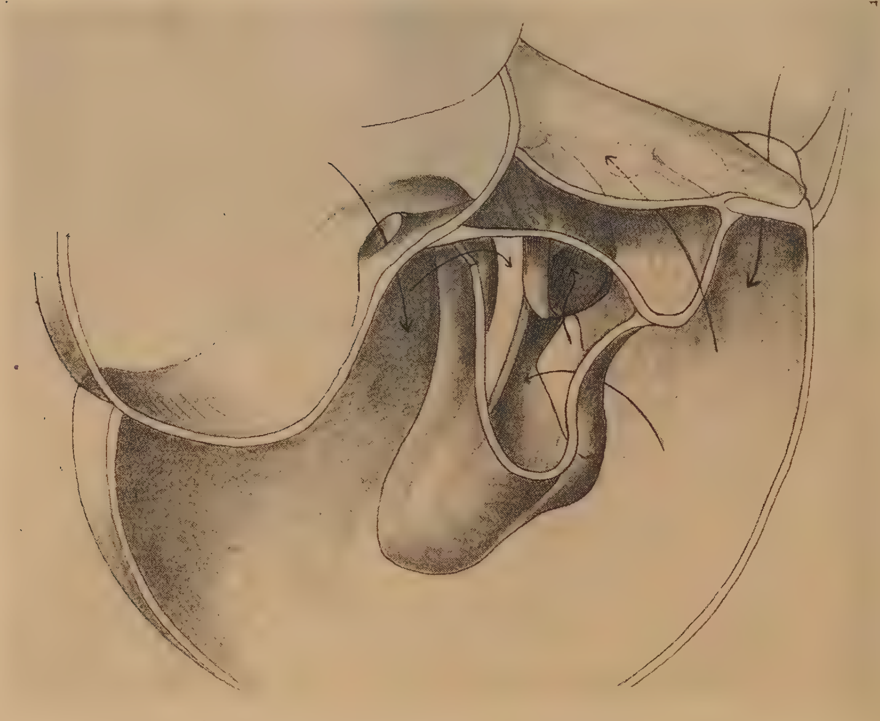


Fig. 260. *Robertinoides oceanica.* Section through last formed chamber, showing foramen to former chamber, slit at free part of toothplate, oral part of the latter, the archal foramen in it, the sacculus, the canal leading to second aperture, the aperture, and the slit between the chamber and the accessorial one.

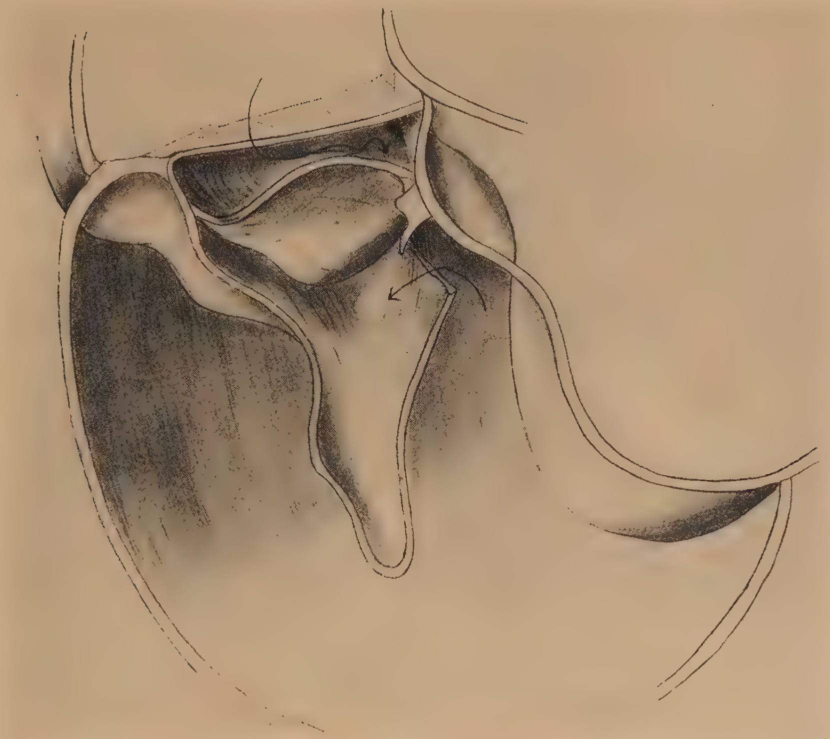


Fig. 261. *Robertinoides oceanica.* Sectioned last formed chamber, seen from apertural side, showing aboral wall of toothplate with canal to dorsal foramen and the slit at the base of the free part. The drawing was taken from a set of glass-plates with successive sections.

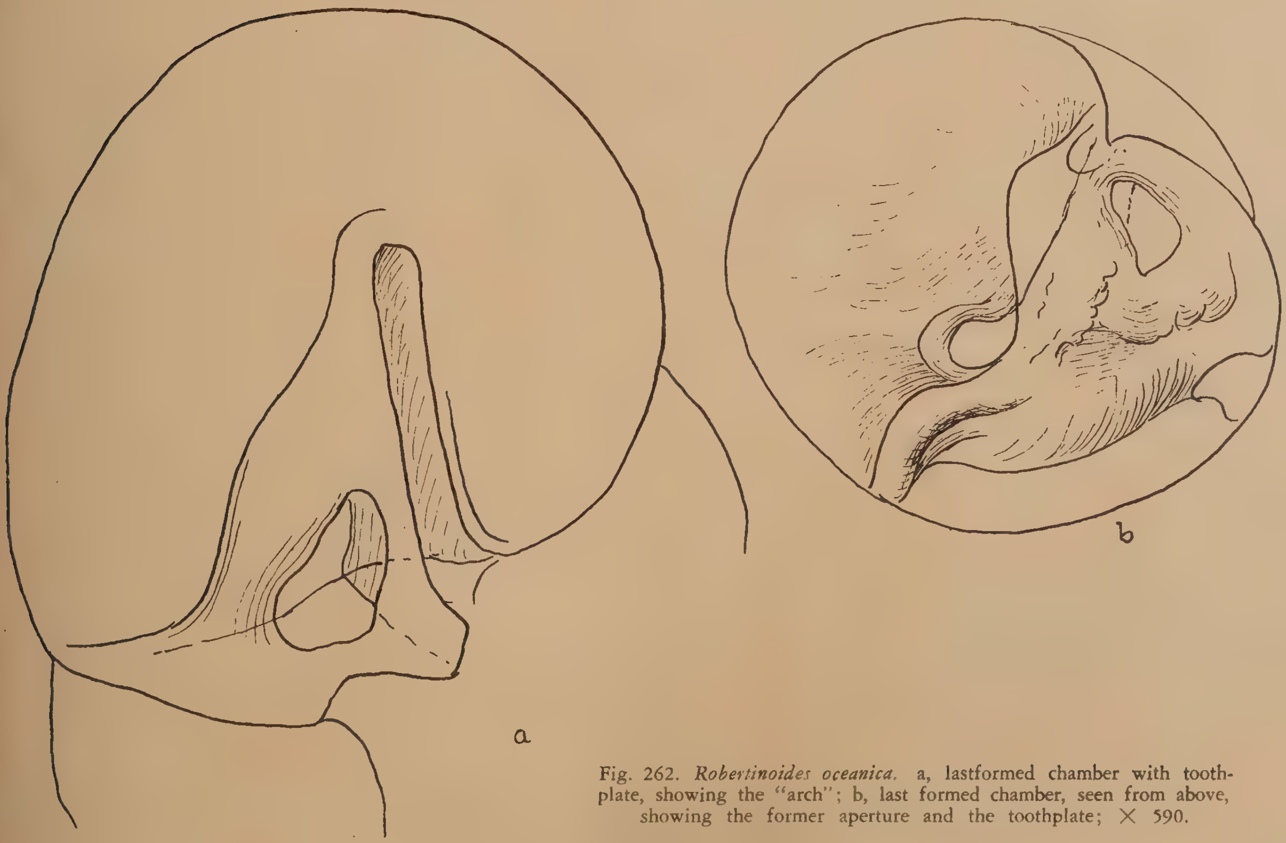


Fig. 262. *Robertinoides oceanica.* a, lastformed chamber with toothplate, showing the "arch"; b, last formed chamber, seen from above, showing the former aperture and the toothplate; × 590.

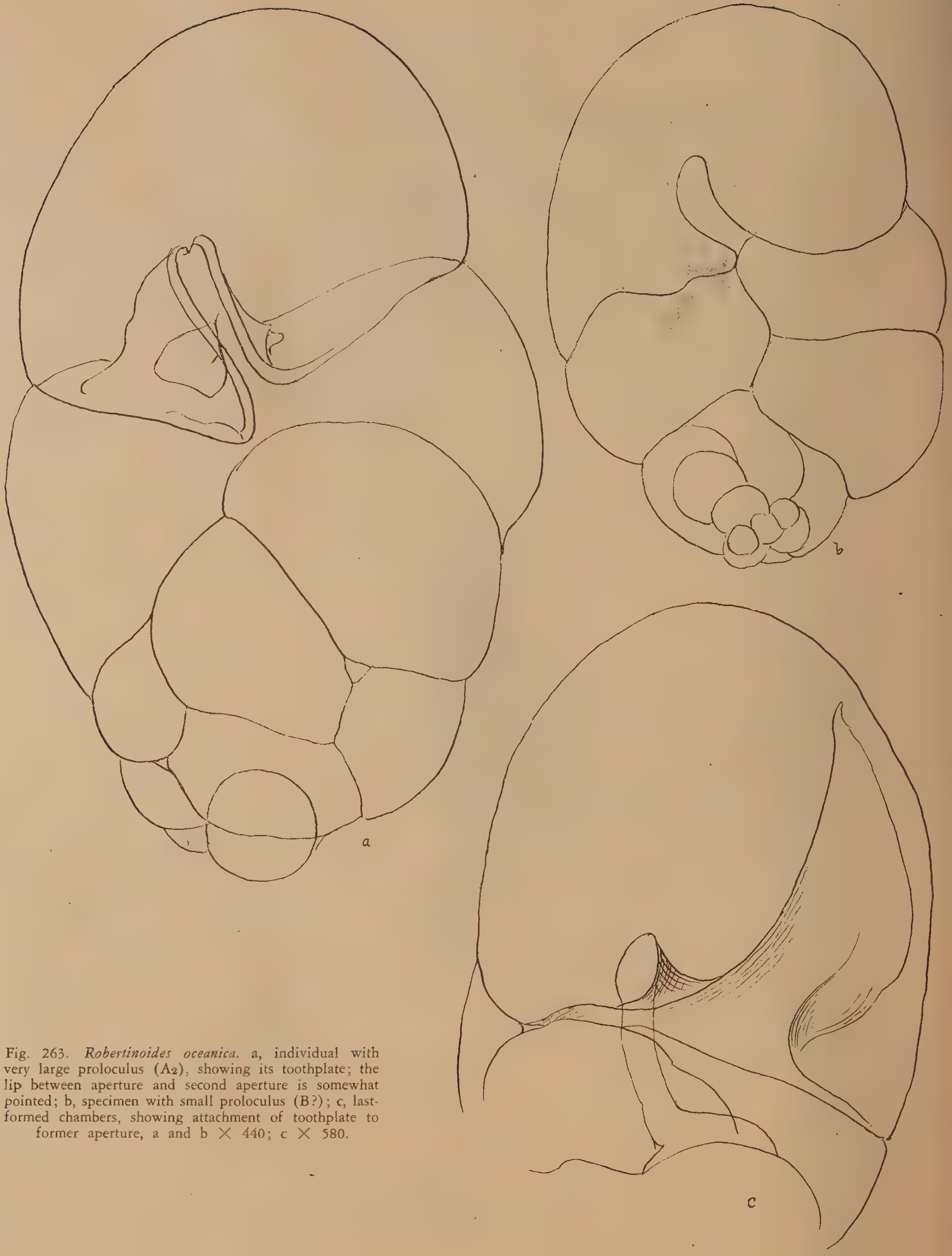


Fig. 263. *Robertinoides oceanica.* a, individual with very large proloculus (A2), showing its toothplate; the lip between aperture and second aperture is somewhat pointed; b, specimen with small proloculus (B?); c, last-formed chambers, showing attachment of toothplate to former aperture, a and b × 440; c × 580.

Indies off Frederikstad. The main aperture in some cases is somewhat more curved upwards, and the wall never shows the fields of pores, but is porous throughout. The species was found too in St. 266: 5° 56′ S., 132° 47′ E., depth 595 m, and 9° 29′ S., 120° 19′ E., depth 330 m.

Muller described only from the Malaya Archipelago, the species *subcylindricum.* He found a moiré surface which is not found in my species. Thus it seems not identical with the species mentioned by Muller.

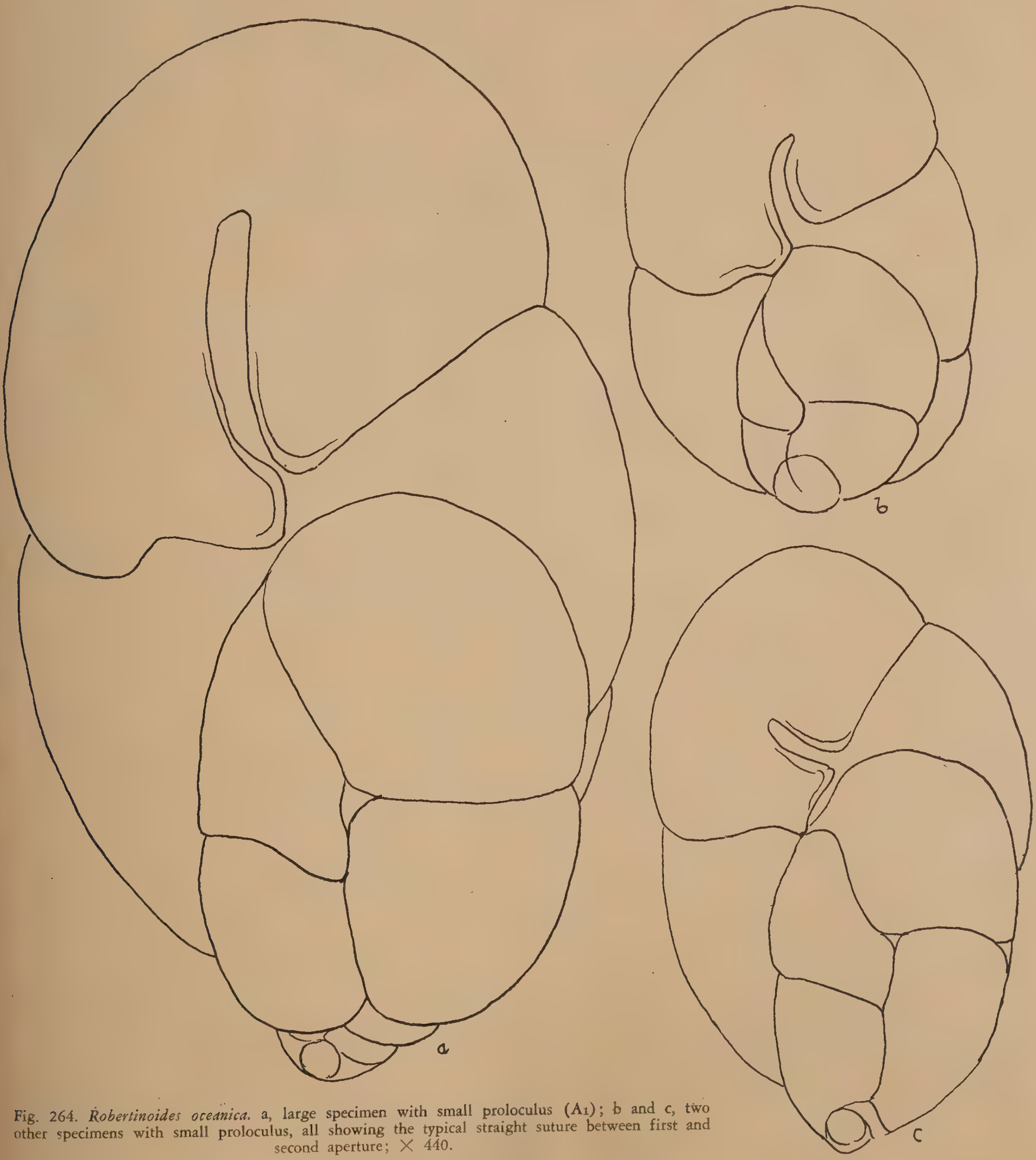


Fig. 264. *Robertinoides oceanica.* a, large specimen with small proloculus (A1); b and c, two other specimens with small proloculus, all showing the typical straight suture between first and second aperture; × 440.

In a very large individual (0,41 mm length) the large, but narrow aperture is curved upwards, while the secundary aperture is separated from it by a small lamina, which is not situated along the sutures of the former chambers, but forms an angle with it.

Other observed individuals show the "normal" structure.

In the large individual the toothplate of the endchamber shows a narrow opening (portal of Höglund) towards the secundary foramen, but in the other two specimens this too shows the same structure as in the West Indian species. Older dorsal apertures always are closed by a porous plate.

In some respects, for instance in the somewhat more compressed shell, the specimens show the features of *R. subcylindrica* (Brady). This may be the real name for our species, but the differences with *R. bradyi* are also rather small.

Two specimens show a proloculus with diameter of 15 μ, a very small specimen (length 0,21 mm) had a proloculus of 22μ diameter.

Genus **Pseudobulimina**

This genus seems to be closest related to *Robertinoides.* It is a *Robertinoides,* in which the chambers have turned down in such a way, that the main and the supplementary chambers both are situated in one level. The protoforamen has been closed, and the deuteroforamen, due to this convolution, is deplaced to the margin between both chamberparts. The dorsal canal, formed by the toothplate opens at the dorsal side of the test, between successive chambers and is closed by a porous plate, as in *Robertinoides.*

The pores always are very fine, and the whole texture of the walls is that of *Robertinoides:* thin, opaque, yellowish, shining on its surface.

There are records of true *Pseudobulimina* from the Eocene on (*Ps. convoluta,* var. *dehiscens* Heron Allen and Earland; Roy. Micr. Soc. Journ. 1924, p. 143, pl. 8, fig. 26-28; *Pseudobulimina glaessneri* Howe et Roberts, Contr. Cushman Lab., Vol. 21, pt. 1, 1945, p. 20, pl. 4, fig. 19, 20).

Pseudobulimina convoluta (Williamson)
(Figs. 265-267)

This very peculiar species was found in two specimens, the one from St. 49a, 8° 23′ S., 119° 4′ E., depth 69 m, Sapeh-Strait, measuring 0,45 mm, the other at 2° 17′ S., 99° 27′ E. depth 377 fathoms. Both specimens were megalospheric, with a proloculus of about 22 μ diameter. This proloculus is followed by a second chamber which remains simple, thus pointing to a bilocular embryo. Then a slightly trochoid spiral of chambers is added, increasing rapidly in size. The umbilical hollow is filled up by ventral chamberparts, which in the later part of the coil are also seen on the dorsal side, as they fold from the ventral side along the inner margin of the chambers toward the dorsal side. At the ventral side these chambers overlap slightly the primary chambers; at the ventral side a triangularly shaped third chamberpart is intercalated between the dorsal ailes of these secundary chamberparts and the normal ones. This dorsal intercalated chamberpart with its triangular closing plates provided with fine pores suggests its homology with the triangular closing plate at the dorsal aperture of *Robertinoides.* The complicated toothplate too points to *Robertinoides.* Thus it may be, that *Pseudobulimina* is nothing but a flat-coiled *Robertinoides.* Its fine pores, very thin walls and yellowish colour of the wall-substance, likewise point in that direction. The umbilical chamberparts are built long after the normal chamber is formed, just as in *Asterigerina.*

The walls are very thin and hyaline, and pierced by very fine dense pores. The colour of the walls is yellowish.

The aperture is loop-shaped, ventrally situated, sutural. In the second umbilical chamberpart the toothplate is situated mainly. The plate is very complicated, shows, however, the typical structure of *Ceratobulimina.* It consists of a folded fan-shaped plate, with a free folded tooth. A flat part of the plate forms the part of the apertural face of the main chamber, while the folded part forms the separating wall of the umbilical chamberpart, which is built when the new toothplate is formed for the next chamber. The main fan-shaped part runs toward the umbilical hollow, and attaches itself at the ventral wall of the main chamber. Between the ventral wall and this plate a triangular part is left free, which later is covered by an outer wall, the triangular third ventral chamber. It stands in connection with the umbilical chamberpart through an opening beneath the toothplate-fan. The attached fan-shaped part of the toothplate runs from the umbilicus toward the inner margin of the test, forming a distinct suture, the sutures between the second chamber and that of the foregoing chamber. A complicated system of folds makes it possible to connect both chamberparts with each other, mainly by a long slit between the aperture and the dorsal wall.

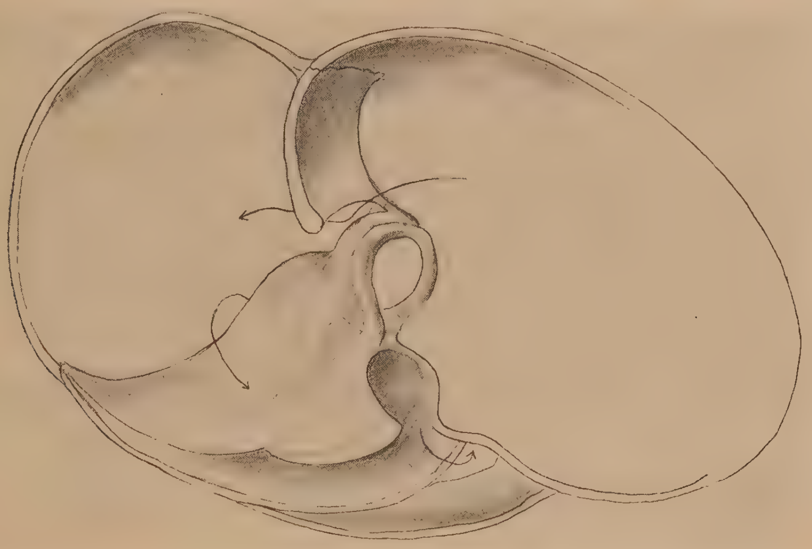


Fig. 265. *Pseudobulimina convoluta.* Last formed chamber, with ventral supplementary chamber, showing the former aperture, the attached part of toothplate, with its free part and the opening to the second chamberlet, its folded part, and the opening to the dorsal small chamberlet. From glassplate-preparation.

In this way the whole test resembles in its characters that of *Robertina,* laid in a flat spiral. The whole form of the test resembles that of *Lamarckina.* The species thus points to a relation with *Robertina, Ceratobulimina* and *Lamarckina.*

It may be, that the species has been already recorded under the name of *Buliminella elegantissima* (d'Orbigny) by Cushman (U.S. Nat. Mus. Bull. 100, p. 168), as when seen from without in dry state it resembles this species in more than one character. As Cushman did not give a figure we cannot be certain about it; the rareness of his species, however, together with the fact, that

B. elegantissima is a species rarely found in the Pacific region, point to the possibility, that the specimen, found in the Philippines is the same, as I found in the Indian Archipelago. Brady got the species from Torres-Strait. Cushman (U.S. Nat. Mus., Bull. 104, pt. 3, p. 109, pl. 18, figs. 4, 5, 1922) did not give new references, but Millet (Roy. Micr. Soc. Journ., 1908, p. 279, pl. 2, fig. 9) recorded it likewise from the Malay Archipelago.

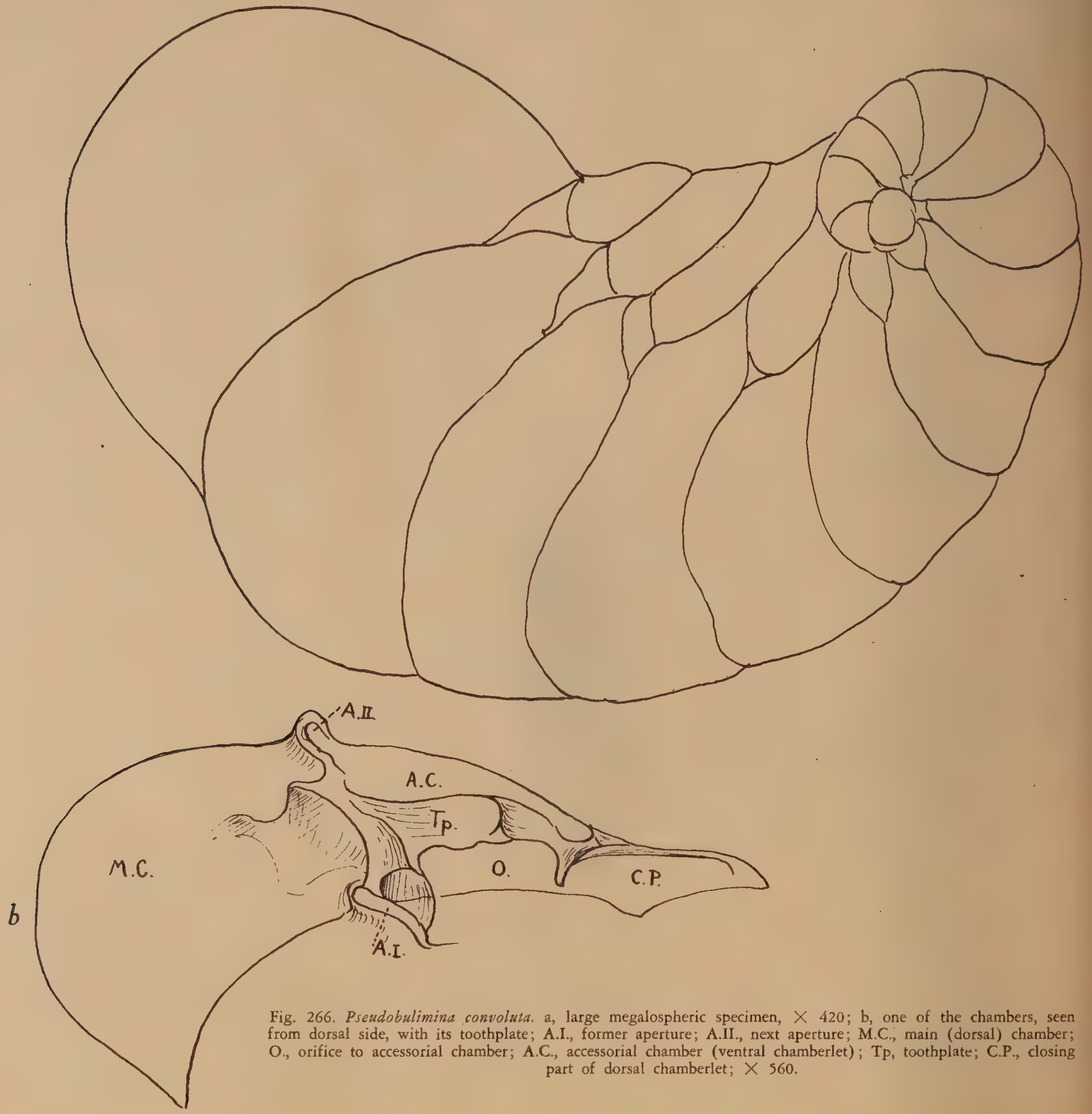


Fig. 266. *Pseudobulimina convoluta.* a, large megalospheric specimen, × 420; b, one of the chambers, seen from dorsal side, with its toothplate; A.I., former aperture; A.II., next aperture; M.C., main (dorsal) chamber; O., orifice to accessorial chamber; A.C., accessorial chamber (ventral chamberlet); Tp, toothplate; C.P., closing part of dorsal chamberlet; × 560.

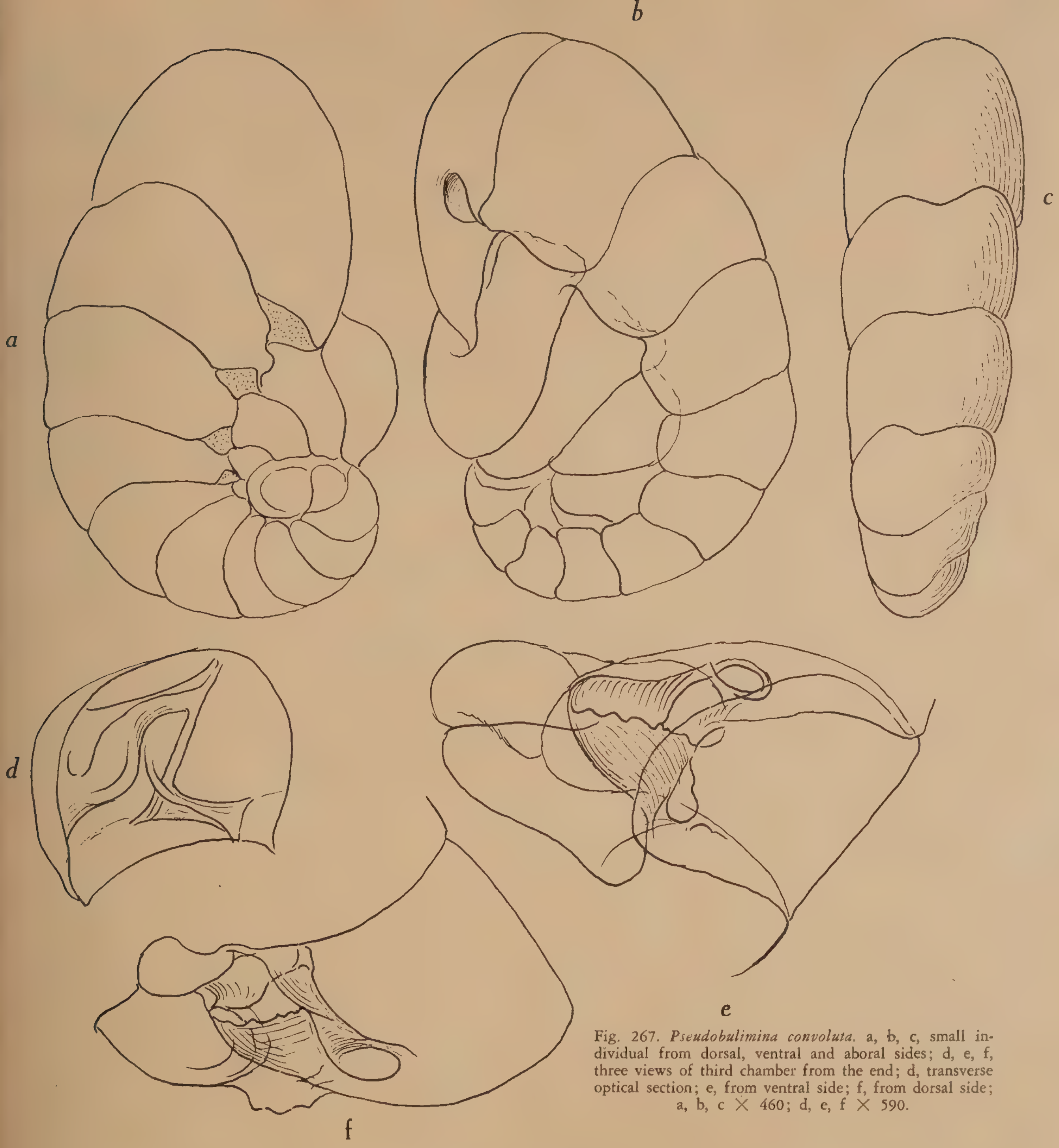


Fig. 267. *Pseudobulimina convoluta.* a, b, c, small individual from dorsal, ventral and aboral sides; d, e, f, three views of third chamber from the end; d, transverse optical section; e, from ventral side; f, from dorsal side; a, b, c × 460; d, e, f × 590.

Family *Alabaminidae*

This family includes the genera *Alabamina* and *Gyroidina.* The genus *Alabamina* has closed its protoforamen more or less totally, and only a groove at the apertural face indicates the inseration of the toothplate at this spot. The deuteroforamen thus is found axially from the groove. In *Alabamina* a toothplate is found, but in *Gyroidina* this plate is obliterated. Both genera show protopores, but for a recent species of *Alabamina, A. tubulifera,* in which deuteropores are found together with protopores. The walls are always more or less opaque, and the deuteroforamen is situated sutural, but in the middle or lower than the middle of the ventral suture. An umbilical hollow never is found, and thus there cannot be any relation with the *Gavelinella*-group, as Brotzen had suggested.

Genus **Alabamina**

(Figs. 268-269)

This genus has received an exhaustive treatment in Brotzen's new work (Sver. Geol. Unders., Ser. C. No. 493, 1948, p. 97-99). Its typical characteristics are the total overlapping without real umbilicus on the ventral side of the chambers, and the very typical aperture, in which the marginal protoforamen is closed up to a more or less distinguishable cavity, whereas the pores always are protopores. Internally a reduced toothplate is found in several species.

I could prove here, that the genus exists in recent times but has always been overlooked, as several species of it have been regarded as belonging to *Eponides.* The inner structure of those *"Eponides"*-species showed me, however, that they all belong to the genus *Alabamina*; a closer examination of the shape of the apertural face underlined this view fully.

In *Alabamina* the protoforamen of *Epistomina* has been obliterated, and only the deuteroforamen remained as the aperture. In consequence the toothplate in *Alabamina* has been reduced too; thus here the deuteroforamen is the only remaining aperture. May be, that from *Alabamina* the genus *Gyroidina* is an offspring, as in that genus the aperture is formed in the same way, as in what has been described as *Eponides.*

In *Alabamina* the foramen always is found axially to the groove which is found marginally from it and more or less parallel to the margin. In Brotzen's mind it is the closed rest of the marginal protoforamen; it may be, however, that it is more likely the rest of the toothplate itself, as in all cases observed this part of the apertural face is lacking pores. In any way the situation points to the foramen (aperture) as being a deuteroforamen.

Alabamina solnäsensis Brotzen

In order to compare real fossil *Alabamina* with the recent new species of this genus I found in the gatherings in the Malay Archipelago, I studied carefully a common species from the Paleocene of the Netherlands, which was kindly given to me by Dr. Van Voorthuysen from the Geological Survey of the Netherlands. It was found in samples from the boring at America, where it occurred in many specimens in depth from 507-570 m. The characteristics of this species are those, described by Ten Dam and Reinhold for their *Eponides gratus* (Reuss); they mention this species from the boring America too, and in the same level. So there cannot be any doubt, that their *Eponides gratus* is the same species as I met with. Brotzen in his paper on the Swedish Paleocene and its Foraminiferal Fauna (Sver. Geol. Unders., Ser. C., No. 493, 1948) described a new species from there under the name of *Alabamina solnäsensis.* His description and figures agree exactly with the species, I found in the boring America in the Paleocene stratum. Brotzen's description runs as follows:

"Test small, rarely more than 0,3 mm in diameter, spiral side slightly convex, umbilical side strongly convex; peripheral margin broadly rounded, distinctly lobate; five chambers in the whorl, on the spiral side elongate, low in the radial direction, slightly inflated, sutures on the spiral side distinctly depressed, straight or fairly curved, on the umbilical side radial, slightly curved, thickened

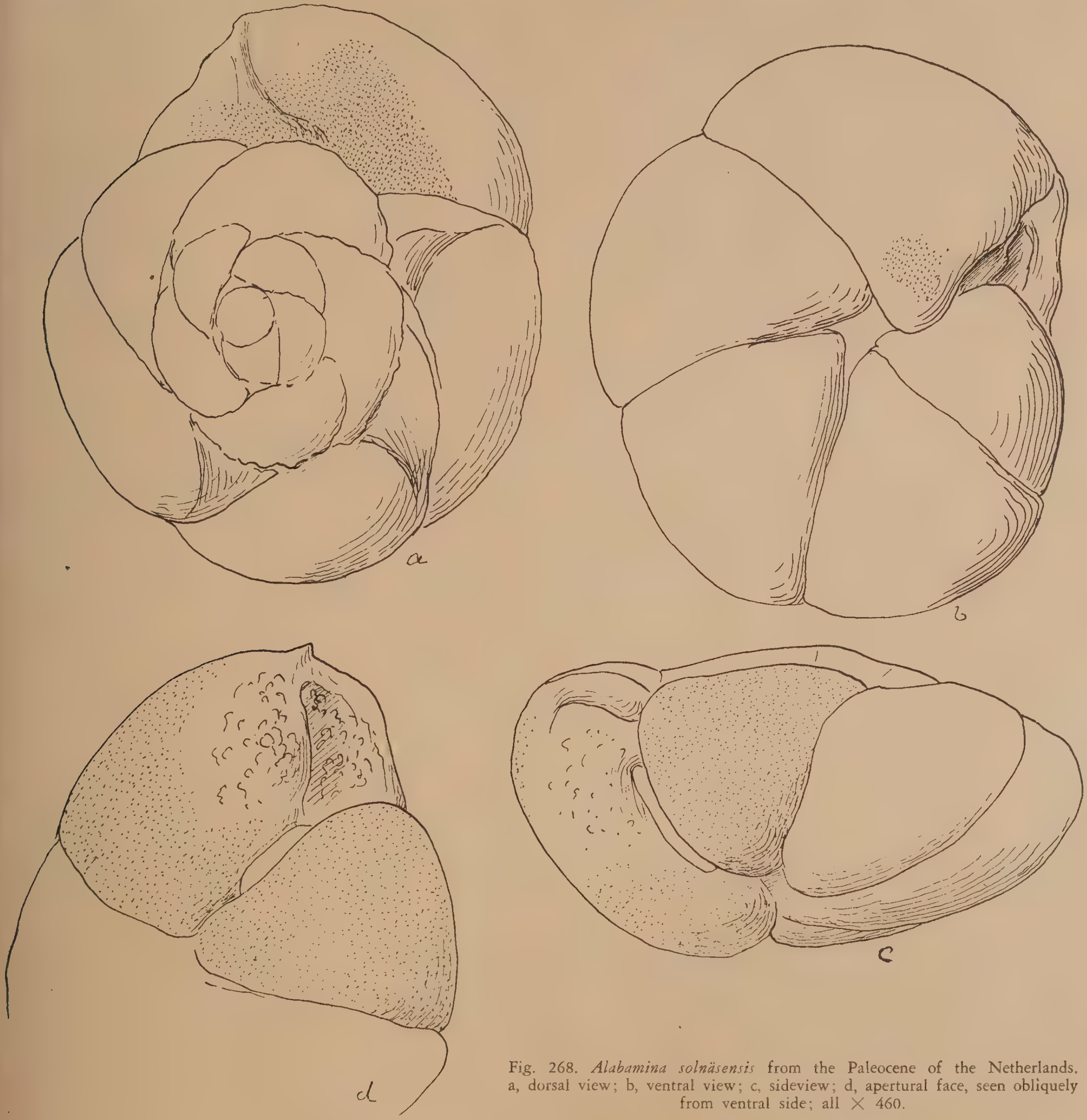


Fig. 268. *Alabamina solnäsensis* from the Paleocene of the Netherlands. a, dorsal view; b, ventral view; c, sideview; d, apertural face, seen obliquely from ventral side; all × 460.

into the centre; septal wall high; scorbis septalis short and deep; tectum strongly projected; aperture large; wall smooth, almost glossy."

Sections made it clear, that there exists a somewhat reduced but distinct toothplate which can be seen from the dorsal side, when the specimen is studied in a clarifier. This toothplate is a solid building, running from the spiral basal wall of each chamber from the former aperture (the septal foramen now) toward the typical short but distinct groove which is found at the apertural face marginally from the aperture and running parallel to the margin. This groove, mentioned by Brotzen as scorbis septalis, thus is the remains of a protoforamen, as the toothplate is attached to its marginal wall for a short part. The septal foramina show with certainty, that the deuteroforamen is somewhat loopshaped, and has no connection with the toothplate itself. The septal foramen is found in the ventral part of the suture. Moreover the part of the apertural face which is formed by the groove and its surrounding, is provided with pores; this too points to a building by the toothplate and consequently to a protoforamen.

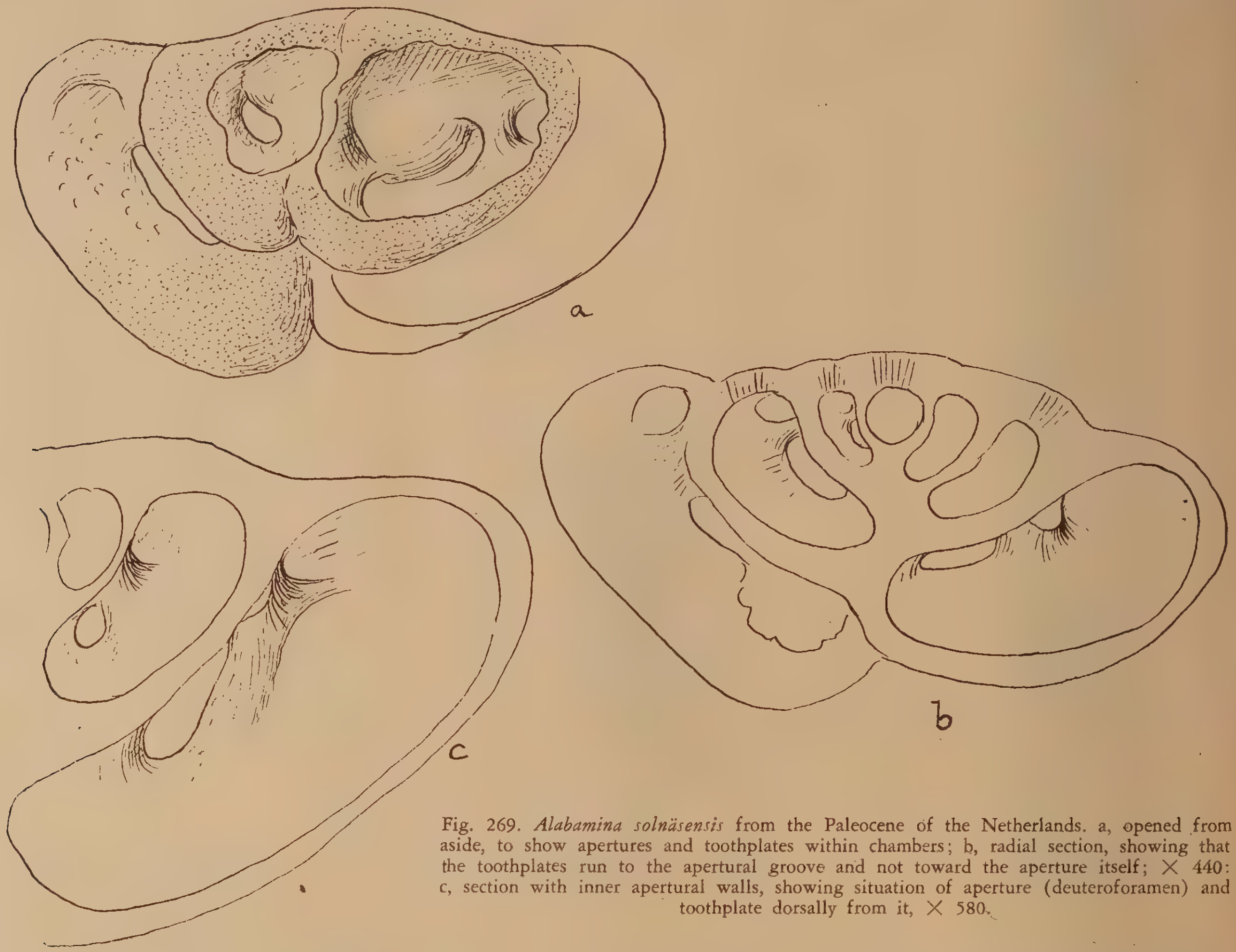


Fig. 269. *Alabamina solnäsensis* from the Paleocene of the Netherlands. a, opened from aside, to show apertures and toothplates within chambers; b, radial section, showing that the toothplates run to the apertural groove and not toward the aperture itself; × 440: c, section with inner apertural walls, showing situation of aperture (deuteroforamen) and toothplate dorsally from it, × 580.

This study leads to the only consequence, that *Alabamina* is a biforaminate genus, belonging to the group of the *Biforaminata deuteroforaminata.*

Alabamina tubulifera (Heron-Allen et Earland)
(Figs. 270-273)

This species was found in abundance in St. 1° 51′ S., 99° 36′ E., depth 683 fathoms; it was moreover found, but always only in few specimens, at St. 8° 15′ S., 118° 56′ E., depth 340 fathoms; St. 2° 26′ S., 99° 58′ E., depth 222 fathoms; St. 49a, 8° 23′ S., 119 ° 4′ E., depth 69 meter.

The test shows a flattened dorsal side, together with a convex ventral one. The walls are opaque, except for the irregular ridges which surround the large deuteropores on the marginal parts of the dorsal walls. These sharp ridges form sort of wallets, more or less circular in shape, just above the margin of each chamber. Within these wallets the coarse deuteropores are opening. These wallets are formed later on, as in the last-formed chamber they are lacking in most cases. More to the centre, each chamber at its dorsal side shows the normal protopores which are very fine, as in all fossil *Alabamina*. At the dorsal side the sutures, running obliquely in respect to the margin, are smooth and scarcely visible, at least in the central part. At the ventral side the chambers are somewhat inflated and leave a broad margin free, which margin, however, does not form a pronounced keel, as is found in *Parrella culter*. The chambers here show the sutures much more distinctly, and here they are slightly depressed. A small part at the centre of the shell is left free by the chambers, but a real open umbilicus does not exist.

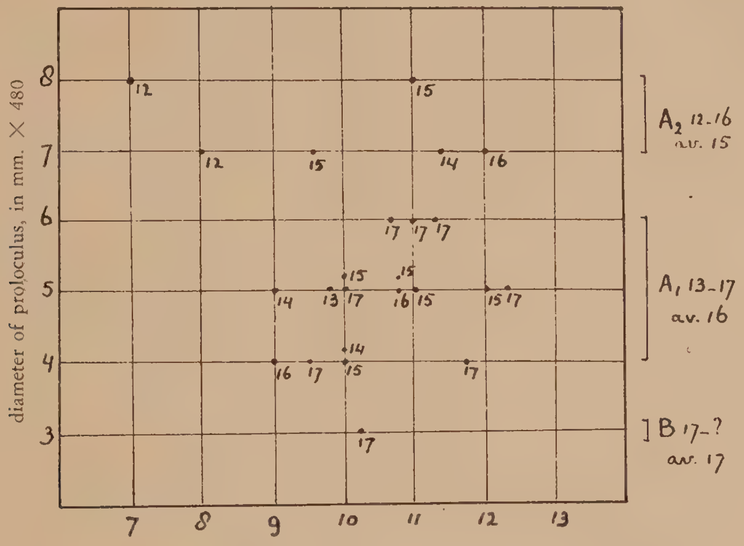


Fig. 270. *Alabamina tubulifera*. Diagram, showing relation between size of proloculus and size of test. The figures indicate the number of chambers. The average of these numbers is 15 in A_2, 16 in A_1 and 17 or more in B.

The number of chambers in the last formed whorl is about 6. The B-form has a proloculus diameter of 6 μ, the A_1-form begins with a proloculus of about 10-15 μ, followed by 14-17 chambers; the A_2-generation with a proloculus of 15-19 μ, shows only 12-15 chambers.

The aperture is a somewhat loop-shaped opening at the umbilical part of the ventral suture of the last formed chamber. It is not totally sutural, but slightly areal. It is found in a groove which marginally suddenly alters its direction, running now parallel to the margin. This margin is slightly protruding form the level of the apertural face, so that this groove parallel to the margin is accentuated. To this groove is attached the toothplate which may easily be detected when a test is studied in a clarifying substance, and seen from the dorsal side. It differs in no character with those toothplates, found in fossil *Alabamina*. It runs from the basal chamberwall, from the neighbourhood of the former septal foramen, toward the groove in the next apertural wall, and it differs in no character whatever from that, given in his beautiful drawings by Brotzen in his paper on the Swedish Paleocene and its Foraminiferal Fauna (Sver. Geol. Unders., Ser. C., No. 493, 1948, p. 98). So I am sure, when comparing this toothplate and the structure of the apertural face with those, found

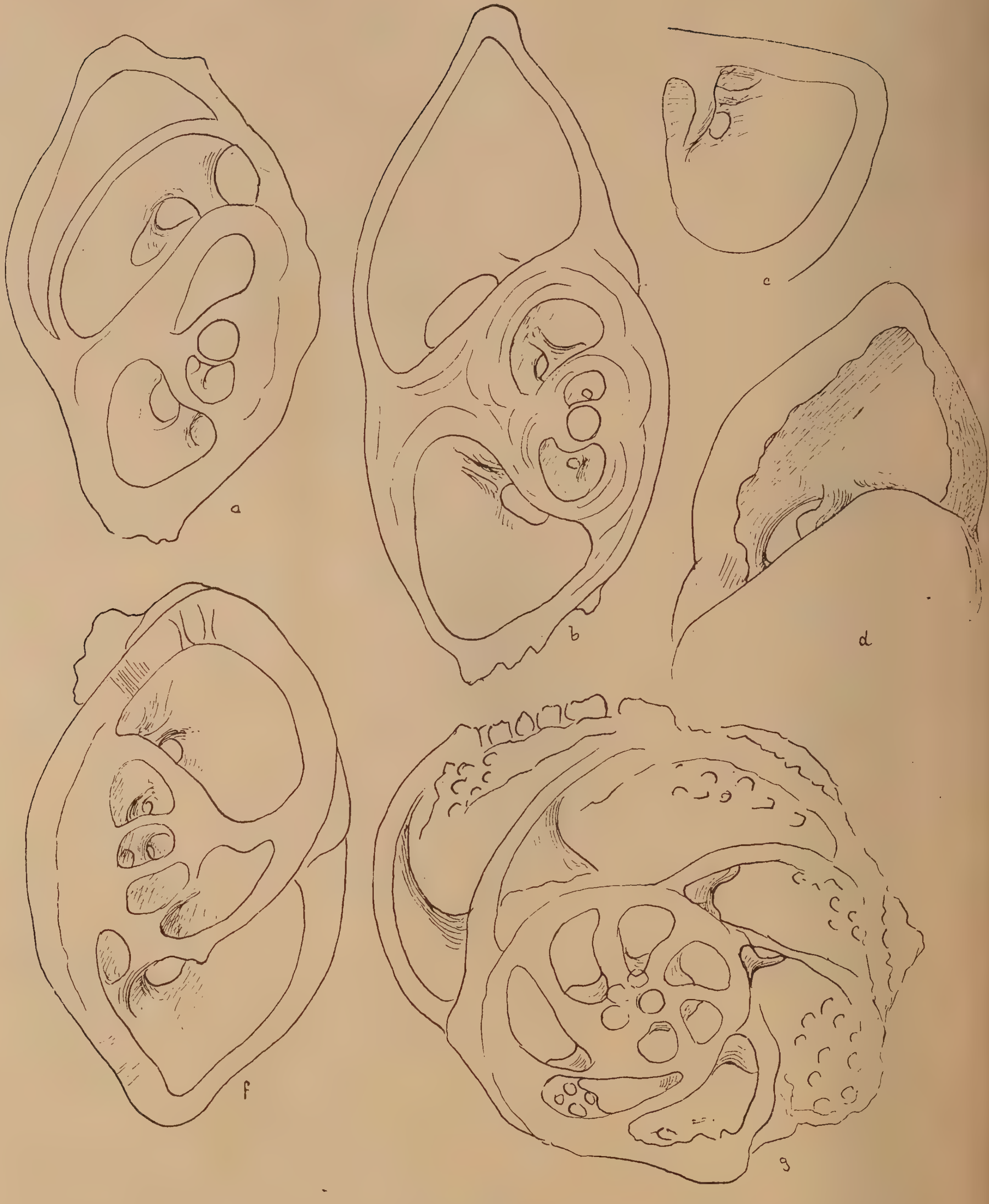


Fig. 271. *Alabamina tubulifera.* a, transverse section, showing foramina and toothplates; b, idem; c, section through chamber with toothplate; d, opened chamber with aperture and toothplate; f, tangential section; g, horizontal section through microspheric specimen, with the toothplates; × 450.

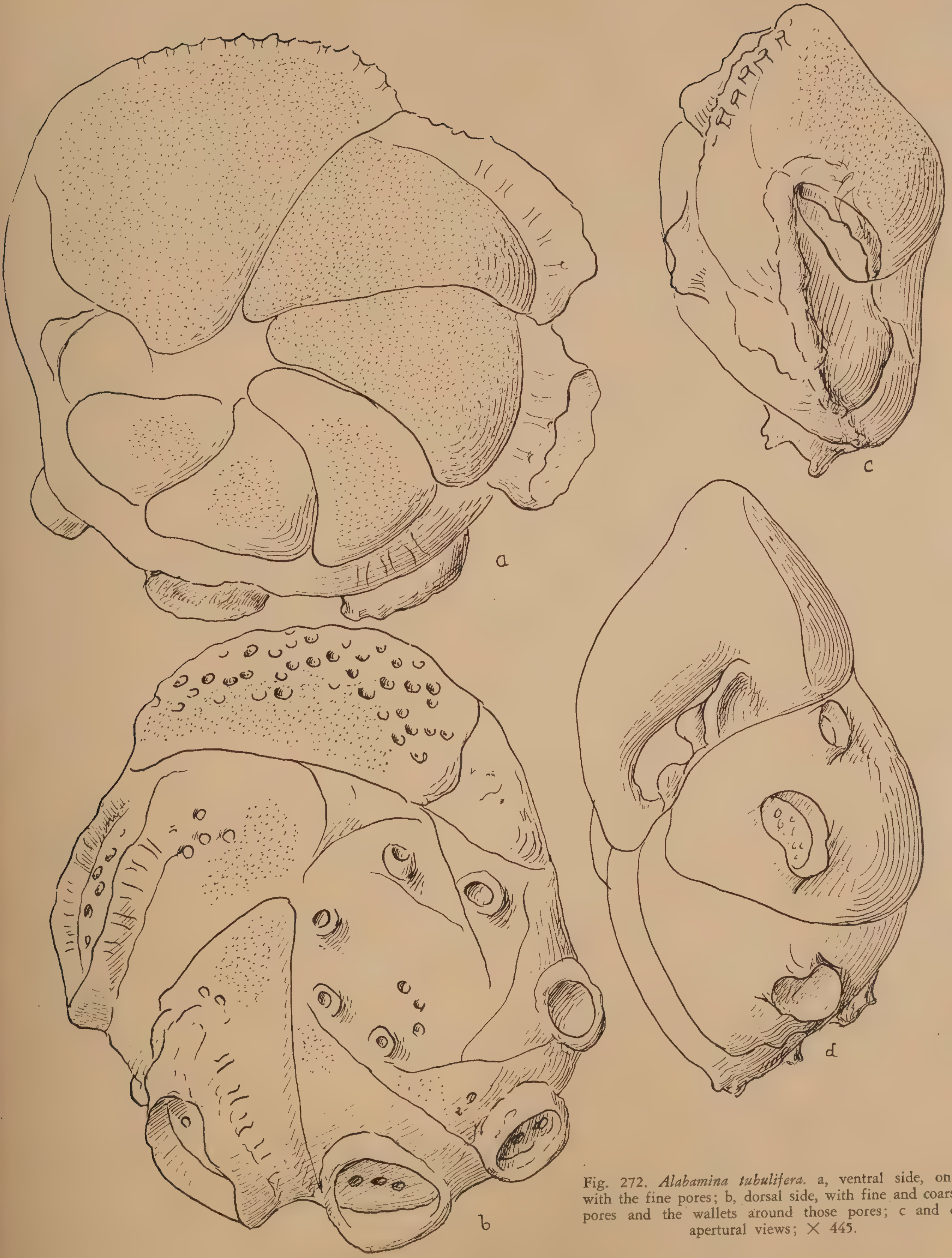


Fig. 272. *Alabamina tubulifera.* a, ventral side, only with the fine pores; b, dorsal side, with fine and coarse pores and the wallets around those pores; c and d, apertural views; × 445.

in the paleocene *Alabamina,* I could study by the kindness of the Geological Survey of the Netherlands, that this recent species from the Malay Archipelago is a real *Alabamina.* I will give here a description of this species.

B-generation. Proloculus-diameter 6 μ; total number of chambers of young specimen 17; diameter of test 0,20 mm. Dorsal side flattened, with protopores, and deuteropores in marginal groups, surrounded by hyaline irregular wallets; sutures smooth and indistinct, oblique. Ventral walls smooth with protopores only; sutures here slightly compressed, walls slightly inflated, sutures slightly oblique. Apertural face with small loop-shaped aperture (deuteroforamen) and a sunken groove parallel to the margin, which is a protoforamen, closed; the toothplate is attached to the marginal border of this groove; the toothplate is of a simple character.

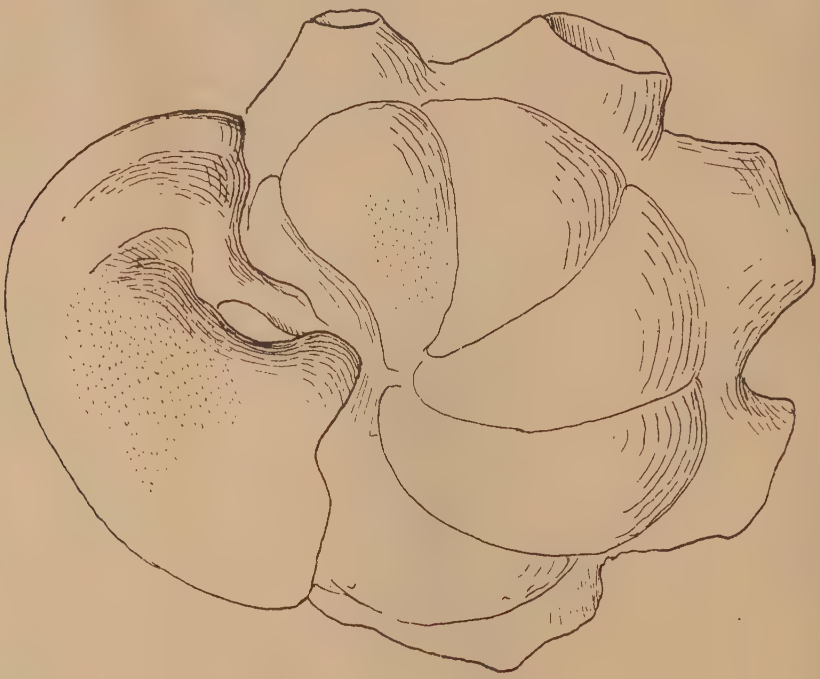


Fig. 273. *Alabamina tubulifera.* Individual seen half from the ventral side, to show the structure of the apertural face, which structure shows much likeness with the genus *Alabamina.* × 480.

A₁-generation. Proloculus 9-13 μ diameter; total number of chambers 13-17, average number 16; besides this, the characters are as mentioned in the B-generation. Diameter of test 0,20-0,26 mm.

A₂-generation. Proloculus diameter 15-18 μ; total number of chambers 12-16, average number 14; size of test from 0,15-0,28 mm.

The species has been described as *Truncatulina tubulifera* by Heron-Allen and Earland (Kerimba Archip.; Zool. Soc. London, Transact., 1915, vol. 20, pt. 17, p. 710, pl. 52, figs. 37-40).

Alabamina procera (Brady)
(Figs. 274, 275)

This species has hitherto been called *Pulvinulina procera,* later *Eponides procera.* It occurred in many specimens in St. 5° 21′ N., 107° 14′ E., depth 43 fathoms.

It shows all characteristics, mentioned by Brady and Cushman. Yet they seem to have overlooked important features, which point directly to *Alabamina.*

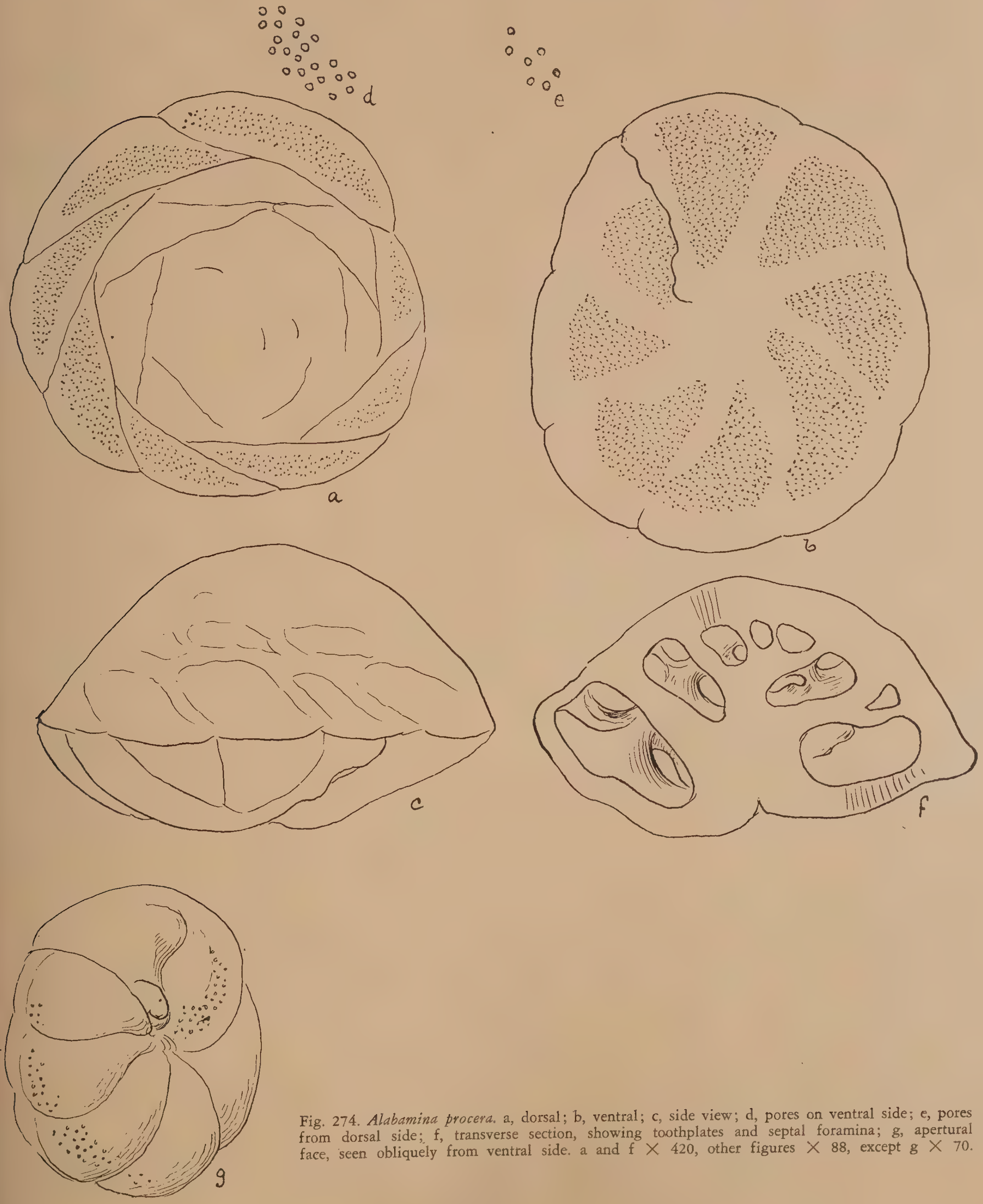


Fig. 274. *Alabamina procera.* a, dorsal; b, ventral; c, side view; d, pores on ventral side; e, pores from dorsal side; f, transverse section, showing toothplates and septal foramina; g, apertural face, seen obliquely from ventral side. a and f × 420, other figures × 88, except g × 70.

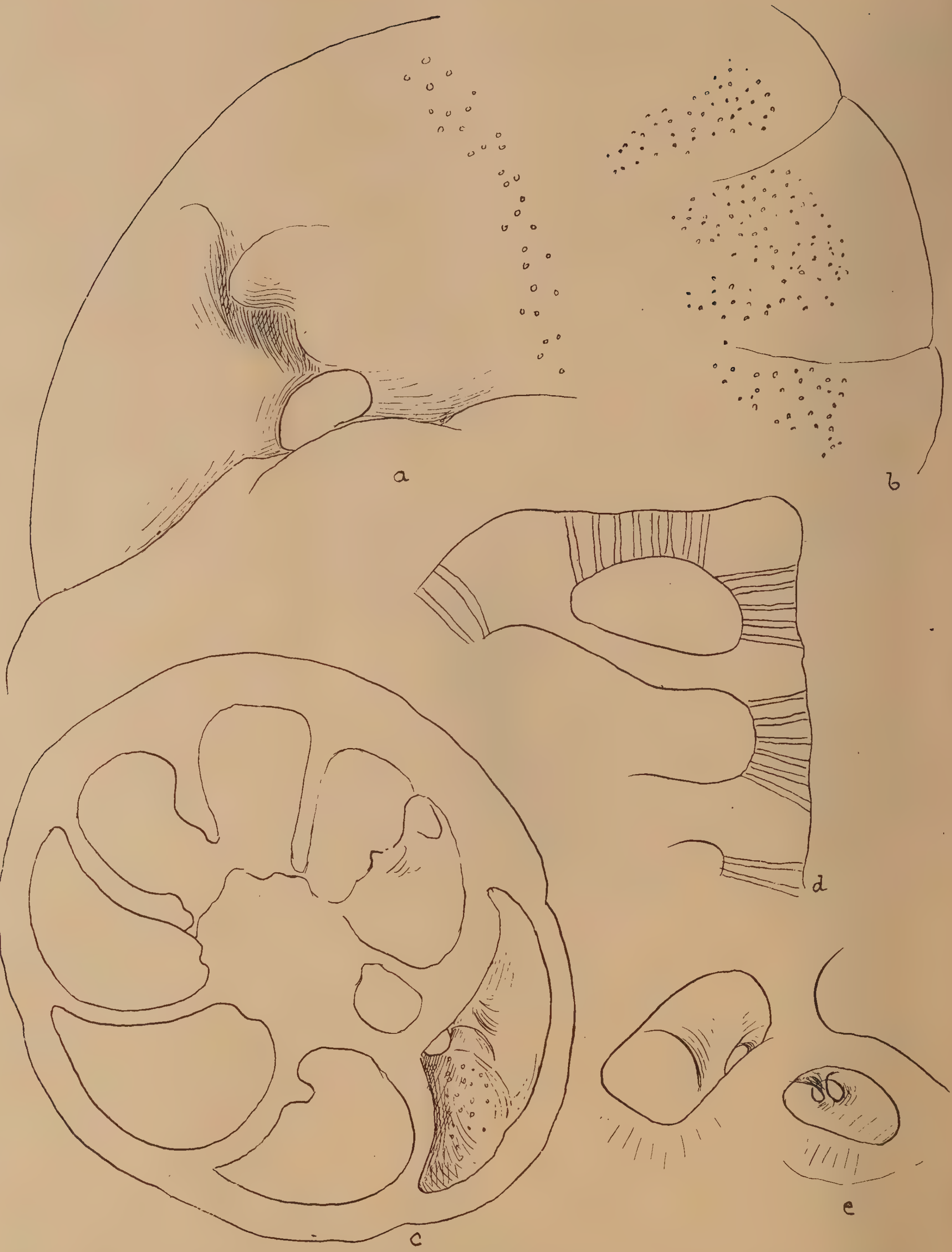


Fig. 275. *Alabamina procera.* a, apertural face, × 420; b, ventral pores at margin, × 420; c, horizontal section, × 88, showing apertural face from within; d, pores from Canadabalsam-preparation; e, part from transverse section, showing toothplates in first chambers, × 420.

These characteristics are the following ones.

At the dorsal side the chambers are seen arranged in a coned spiral; they are much longer than broad, as in all real *Alabamina.* The walls at the dorsal side show distinct, rather coarse pores, and are very thick and not hyaline, but rather opaque. The sutures are indistinct, as the thickening of the wall, especially at the centre of the test, has covered them. They are situated very much obliquely to the margin.

At the ventral side the sutures are directed radially, as in *Alabamina.* 7-8 chambers are visible here. The distinct pores are lacking underneath the margin, where the shell substance is rather clear. A slight umbilicus, filled up with secondary chalk, is left free in the centre.

As in all *Alabamina*-species, the apertural face lacks the pores totally. The aperture (deuteroforamen) is an open arched slit at the suture, ventrally, near to the axis of the test, as in all other *Alabamina*-species. Marginally to this suture there is a peculiar and distinct groove in the apertural face, so that the marginal part of it is much inflated, whereas the sutural part is sunken down. This groove is typical for all *Alabamina.* In the aperture one may, when observing obliquely, disclose a toothlike projecting part of the inner wall. Sections made it clear, that this is a real toothplate, not differing from those, found in Paleocene *Alabamina.*

All these characteristics point so strongly to the genus *Alabamina,* that I do not hesitate to call this species as such.

Genus **Gyroidina**

It often is very difficult to conclude, whether a species belongs to *Gyroidina, Gyroidinoides* or *Eponides.* Yet these three genera show, when analysed thoroughly, no real relation with each other. I will try to give a sharp definition of these three genera.

Several species of *Gyroidina* have been called by modern authors *Eponides,* while e.g. *Gyroidina soldanii* has been brought recently by Brotzen under the genus *Gyroidinoides* (S. Ver. Geol. Unders., Ser. C., No. 493, 1948, p. 76: *Gyroidinoides soldanii,* var. *octocamerata*).

Genus *Gyroidinoides*:

Test trochoid, dorsally with all chambers visible, ventrally only those of last whorl. Dorsal and ventral sutures nearly radial. Dorsal side mostly without pores, ventral side with protopores. Umbilicus open, and deuteroforamen with an axially situated lip covering partly the umbilical hollow and forming at least in the last formed chambers an open connection with the umbilical cavity.

Genus *Gyroidina*:

Test trochoid, dorsally with all chambers visible, ventrally only those of the last whorl. Dorsal and ventral sutures nearly radial. Dorsal and ventral sides, together with rounded margin, covered by protopores all over the surface. Often last formed whorl somewhat raised above the general dorsal surface. Umbilicus closed, deuteroforamen situated about or under the middle of the ventral suture, sutural throughout.

Genus *Eponides*:

Test trochoid, dorsally with all chambers visible, ventrally only those of the last whorl. Dorsally the sutures more or less obliquely in regard of the margin. Both sides and margin covered by protopores, always very fine as in *Gyroidina.* Umbilicus closed. Foramina are protoforamina, situated about the middle or slightly above the middle of the ventral suture, and not sutural but areal.

This analysis of the three genera at once makes it clear, that they cannot be distinghuished by studying them in dry state outwardly, but that only a transverse section, revealing the situation and shape of the septal foramina of the later chambers, can give us the true state of a species in these three genera. This is the reason, why so much confusion has arisen.

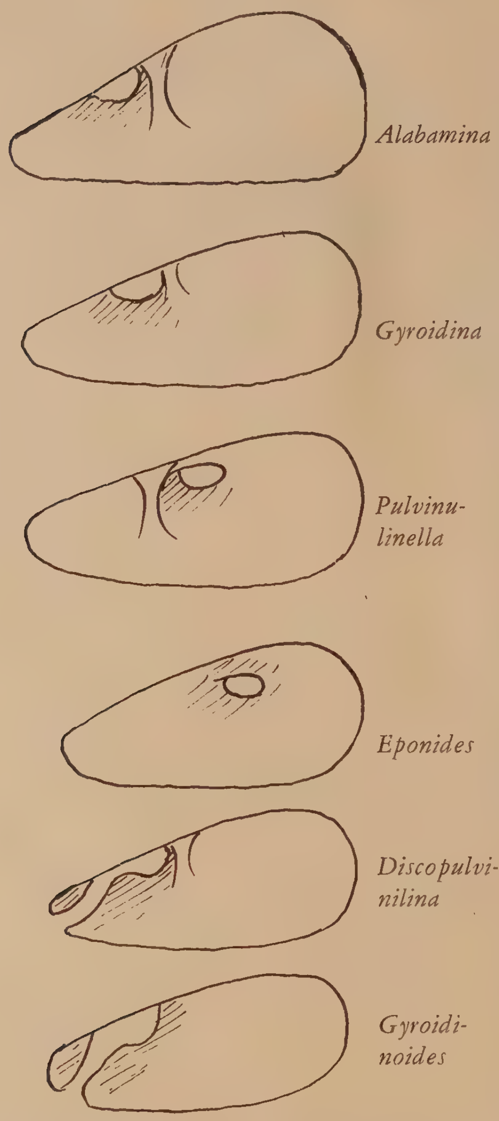


Fig. 276. Schematic figure, showing the differences between *Gyroidina, Eponides* and *Gyroidinoides,* together with the three genera, from which these genera may have derived. A loop-shaped septal foramen, in areal situation, always indicates in these coiled Foraminifera that it has derived from a protoforamen.

The genus *Gyroidinoides* is very closely allied to *Gavelinella,* as Brotzen has pointed out. The *Valvulineridae* however are very closely allied to the genus *Discopulvinulina,* and thus have to be placed among the *Conorbida.* Both genera *Gyroidina* and *Eponides* on the other hand, lacking any indication of a connection with the, moreover, closed cavity of the umbilicus, and thus not showing any indication of an opening into that cavity, cannot belong to the *Conorbida* at all. Their relations have to be sought among the *Ceratobuliminidae,* in which group two distinct genera show characters (the fine pores as well as the closed umbilicus) resembling those of the two genera, here in discussion. These two genera are *Alabamina* and *Pulvinulinella.* A third genus, *Parrella,* shows in its species the tendency to have deuteropores, and thus must be the ancestral genus of the genus *Cibicides,* as *Parella* too shows the closed umbilicus.

The genus *Alabamina,* as has been stated by Brotzen and myself, shows deuteroforamina as septal foramina. I stated, that some species, hitherto mentioned as *Eponides,* are in reality *Alabamina.* The fact, that *Alabamina* shows deuteroforamina, points at once to *Gyroidina* as its descendant (fig. 276).

The genus *Pulvinulinella* shows protoforamina without any doubt, as its foramina show in several species very clearly developed toothplates connected with the foramina. As, on the other hand, its pores are always very fine and the umbilicus in *Pulvinulinella* is closed, one may come to the conclusion, that *Eponides* is a derivate from *Pulvinulinella.*

So, both genera, *Gyroidina* and *Eponides,* are offsprings from the *Ceratobuliminidae,* and thus I have placed them into that family. *Gyroidinoides* on the other hand is an offspring of the *Conorbida,* and so it has to be placed, together with its allies, *Gavelinella* and *Valvulineria, Discovalvulineria* and *Gavelinopsis,* into the sub-ordo of the *Conorbida.*

Contrary to Brotzen, I could prove with certainty, that, as the genera *Cibicides, Suphoninella* and *Siphonina* show protoforamina, they have to be regarded as offsprings of *Parrella,* and cannot be placed together with the *Valvulineridae.*

Gyroidina soldanii d'Orbigny
(Figs. 277, 278)

There were some scattered specimens at the stations 9° 29′ S., 120° 19′ E., depth 330 fathoms and 1° 51′ S., 99° 36′ E., depth 683 fathoms, which I believe to belong to this variable species.

Dorsal side flat or slightly convex, the last-formed spiral suture depressed, ventral side convex,

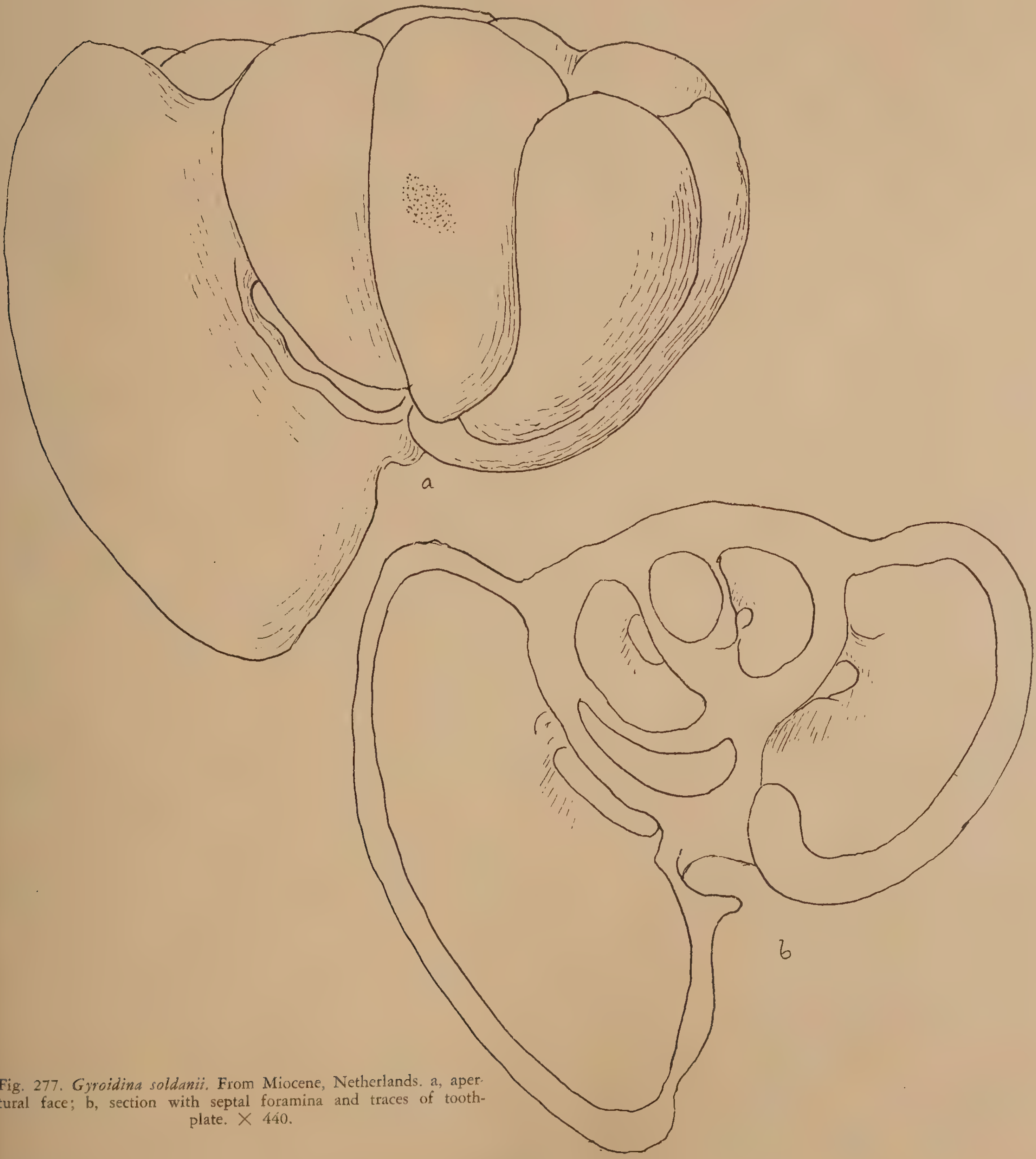


Fig. 277. *Gyroidina soldanii.* From Miocene, Netherlands. a, apertural face; b, section with septal foramina and traces of tooth-plate. × 440.

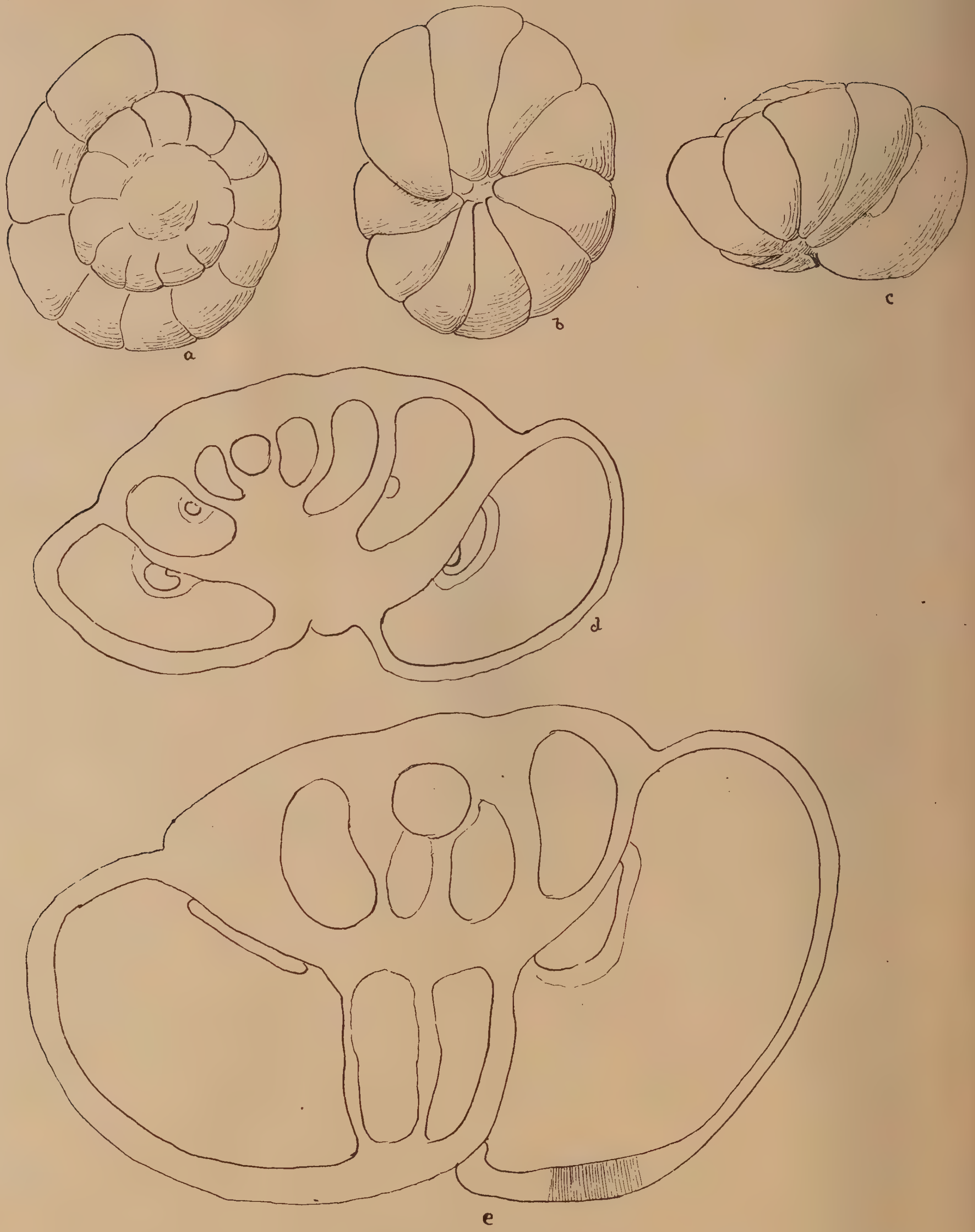


Fig. 278. *Gyroidina soldanii.* a, b, c, individual from Pacific; d, transverse section; e, section through another specimen. a, b, c × 95; d, e × 440.

with incavated but closed umbilicus, periphery rounded. Walls very much opaque, those of the last-formed whorl thin, dorsal side thickened by secondary chalk layers, so that the initial part is not discernable from the dorsal side. Sutures on dorsal side nearly radial, as are those on the ventral side, slightly depressed. Wall polished, with very fine pores all over. Aperture an elongated slit in the middle of the ventral suture; septal foramina likewise situated in the middle of the ventral suture, small, rounded, often with a small lip at the suture.

Diameter in the material not larger than 0,7 mm.

I was able to study many specimens, deriving from the Miocene of Beeringen deepboring, depth 245 m, kindly given to me by the Geological Survey of the Netherlands. They showed but minor differences with those, found in the Pacific, and gave some new suggestions as to the real nature of the genus. As in *Gyroidina broeckiana,* the older septal foramina showed traces of a loop-shaped nature and a reduced toothplate, whereas those of the last-formed coil were much more elongate and showed no traces of a toothplate. The toothplate is found marginally from the septal foramina, thus indicating, that these sutural foramina, which never show the loop-shaped nature, are deuteroforamina.

Gyroidina tenera (Brady)
Figs. 279, 280)

This species which occurs, though never abundant, in most of the samples in the Archipelago, has been identified by Cushman (U.S. Nat. Mus., Bull. 104, pt. 8, 1931, p. 53) with *Pulvinulina umbonata* Reuss, and subsequently he calls it *Eponides umbonata.* The description of Cushman runs as follows:

"Test biconvex, varying much in relative amount in different specimens, periphery acute to rounded; chambers distinct, from five in the young and megalospheric forms to eight in the adult microspheric form, very little inflated, increasing uniformly in size as added; sutures distinct, those of the dorsal side in the young straight and nearly radial, in the adult slightly oblique, on the ventral side usually with a characteristic sigmoidal curve; wall smooth, very finely perforate; aperture usually about midway between the periphery and umbilical region of the ventral side, often with a slightly thickened border or even a slight lip".

It seems, that especially the number of chambers in the last formed whorl is a character, which can be used in these different species of *Gyroidina.* In *G. soldanii* it ranges from 9-11, in *G. tenera* from 5-7, and in *G. broeckiana* from 6-8; the latter species moreover is characterised by its strongly convex dorsal side.

Gyroidina umbonata (Reuss), which has been identified by Cushman (U.S. Nat. Mus., Bull. 104, pt. 8, p. 52-56) with *Eponides* (*Truncatulina*) *tenera* (Brady), shows not such a wide range in variation, as has been mentioned by Cushman. I am sure, that *G. tenera* is a different species, and that a closer examination in statistical way will reveal several species, now regarded too as *G. umbonata.* The species is much more a *Gyroidina* than an *Eponides,* as the dorsal sutures are radial and not oblique and the septal foramina are sutural and not areal.

*Gyroidina broeckhiana (*Karrer)
(Figs. 281, 282)

Test nearly equally biconvex, nearly circular in side view. Chambers 7 or 8 in the final whorl in the megalospheric specimens, narrow. Sutures slightly depressed, a slight "channel" between the

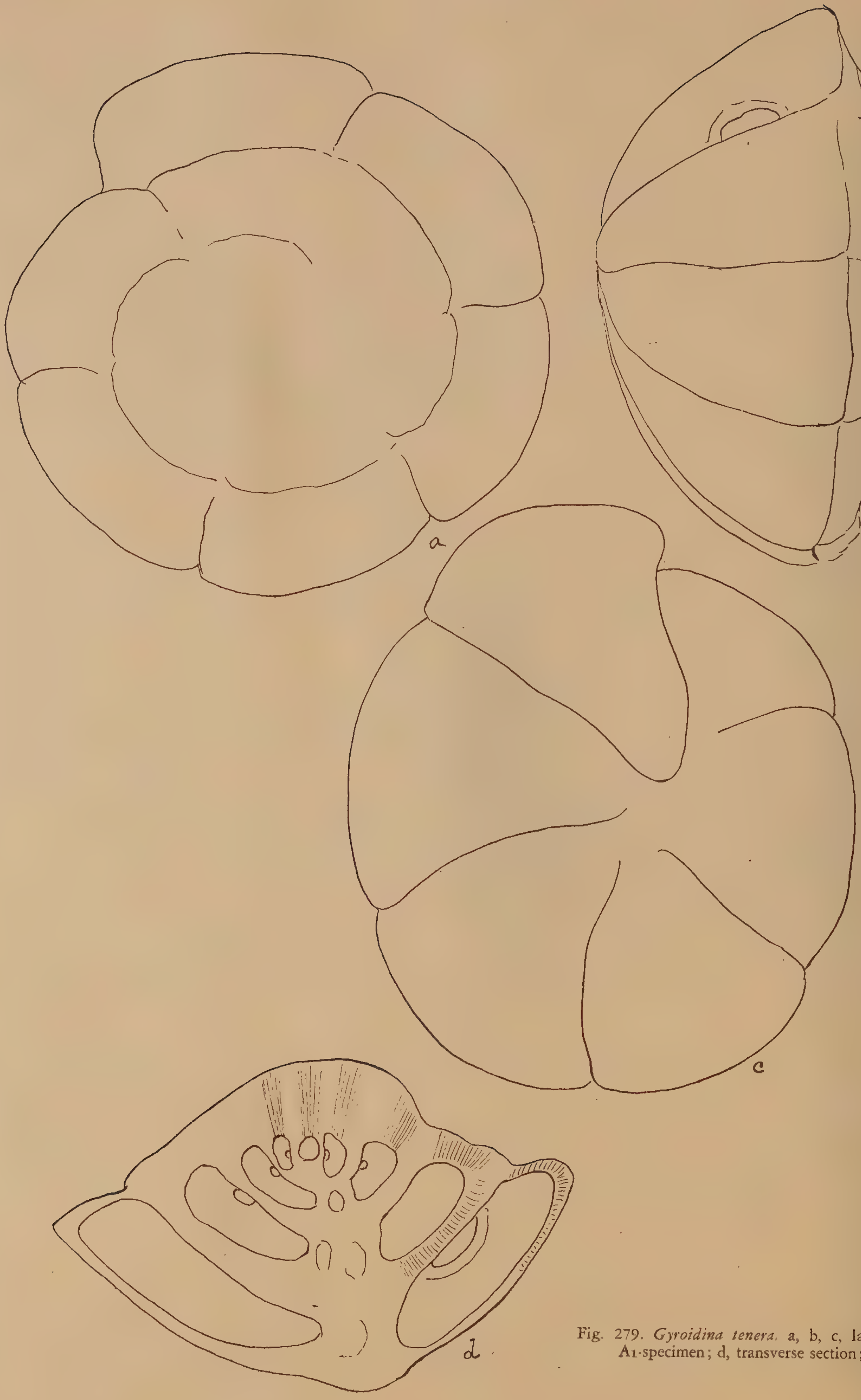


Fig. 279. *Gyroidina tenera.* a, b, c, large, probably A1-specimen; d, transverse section; × 80.

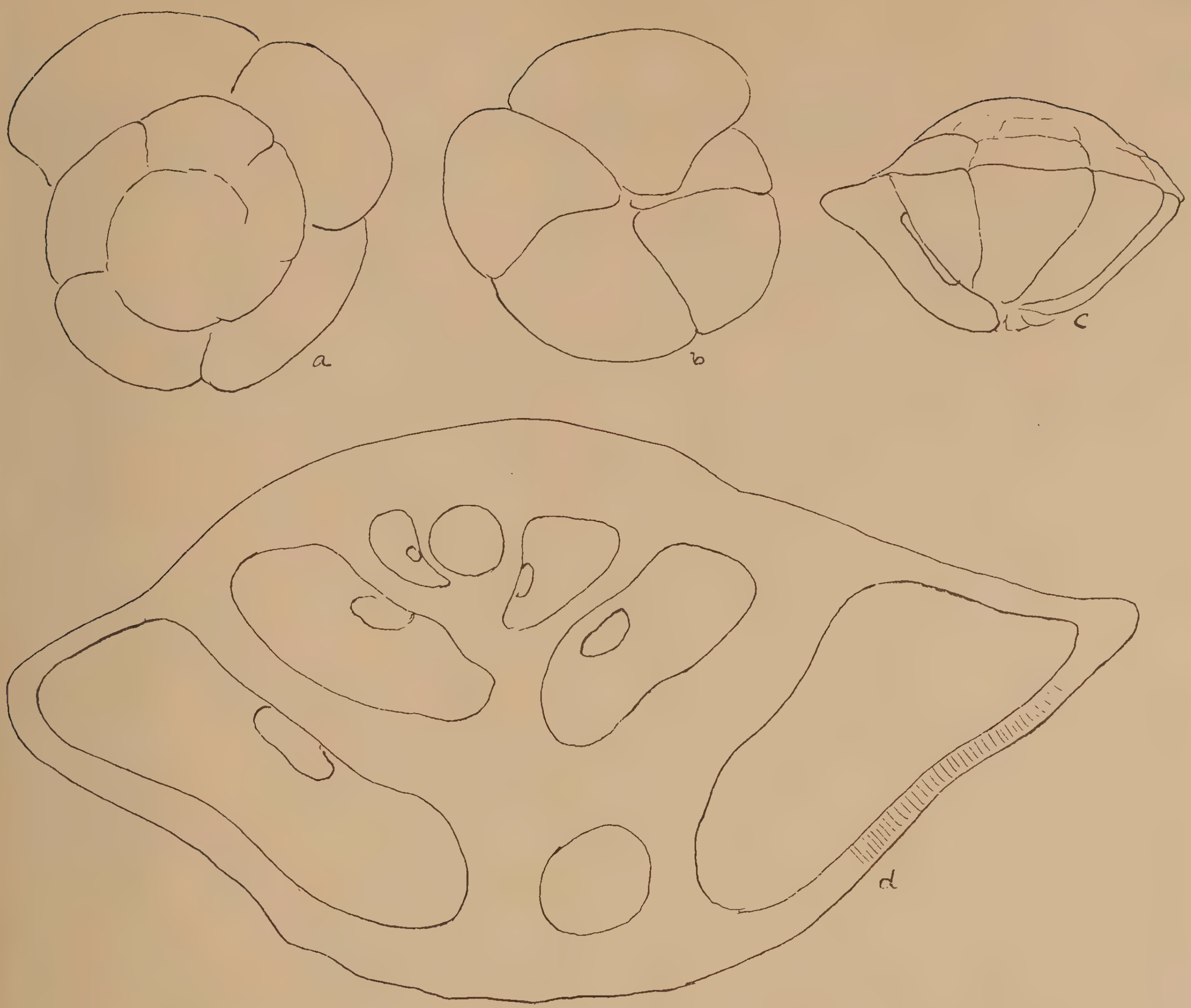


Fig. 280. *Gyroidina tenera.* a, b, c, small megalospheric specimen, × 95; c, transverse section, × 460.

last formed whorl and the previous one dorsally, as each later whorl has its chambers somewhat risen above the surface of the former coil. Umbilical region filled-up with smooth shell-material, together with the ventral sutures. Surface smooth, shining, with indistinct longitudinal ridges on the dorsal side. Aperture seemingly a ventral slit, with a slight thickened lip, but in reality totally ventral, near the umbilicus, and often double. The aperture always has a thickened lip, and shows typical loop-shaped structure. The pores are very fine, only at the sutures lacking. The whitish walls, opaque and thick, point to *Gyroidina.* The species seems to stand between real *Eponides* and real *Gyroidina,* but the opaque shell-material points more to *Gyroidina* than to *Eponides*, though the dorsal side is very convex and high.

Transverse sections show clearly, how erroneous the description of an aperture may be, when seen from the outside. For when observing the aperture from outside, the lip above it stretches along the suture up to near the margin, while sections make it certain, that the real aperture is confined to a narrow opening just at the umbilical ventral side of the chamber. Several secundary apertures are found, especially in later chambers. They may have connection with propagation. They often

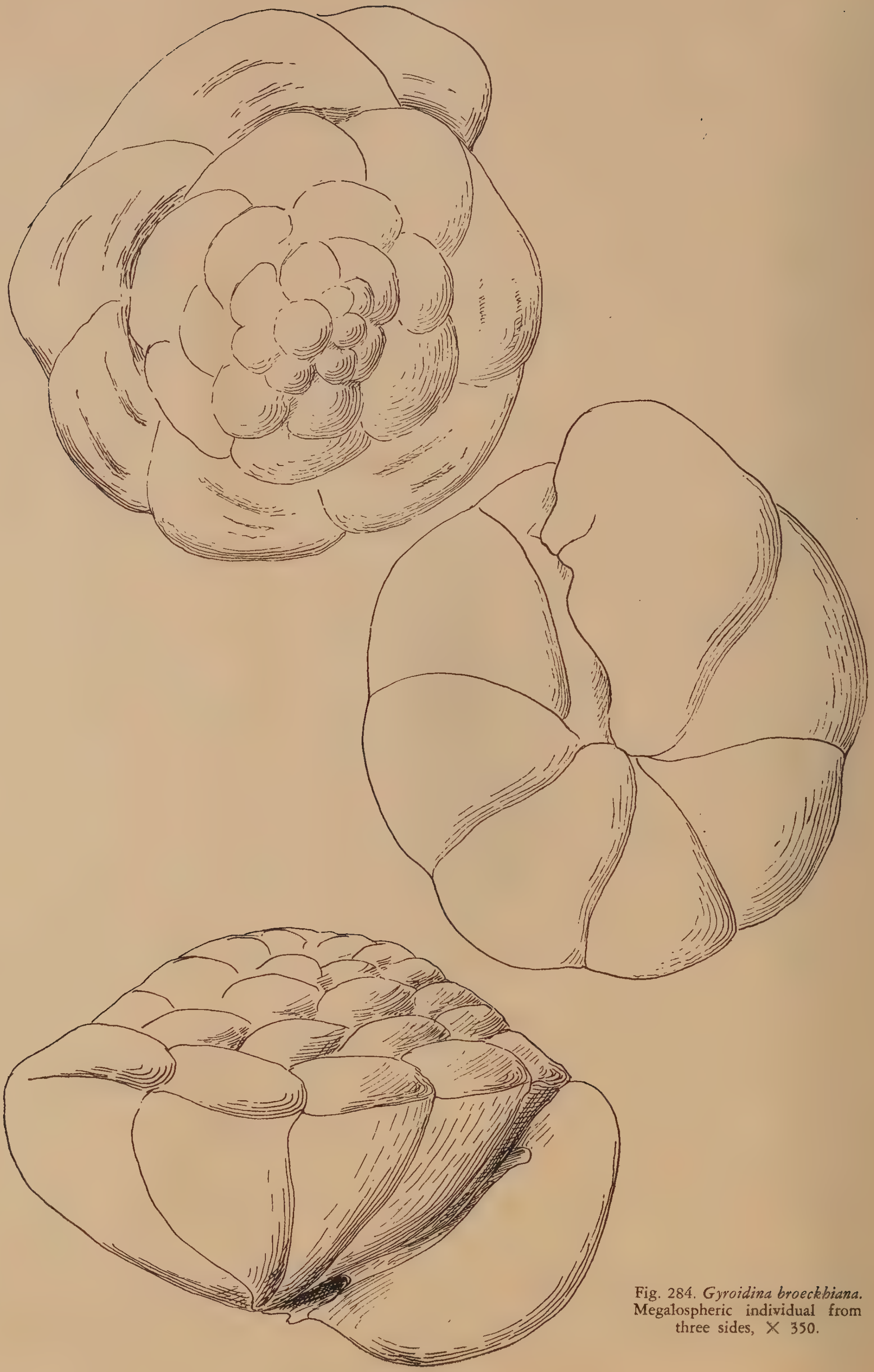


Fig. 284. *Gyroidina broeckhiana.* Megalospheric individual from three sides, × 350.

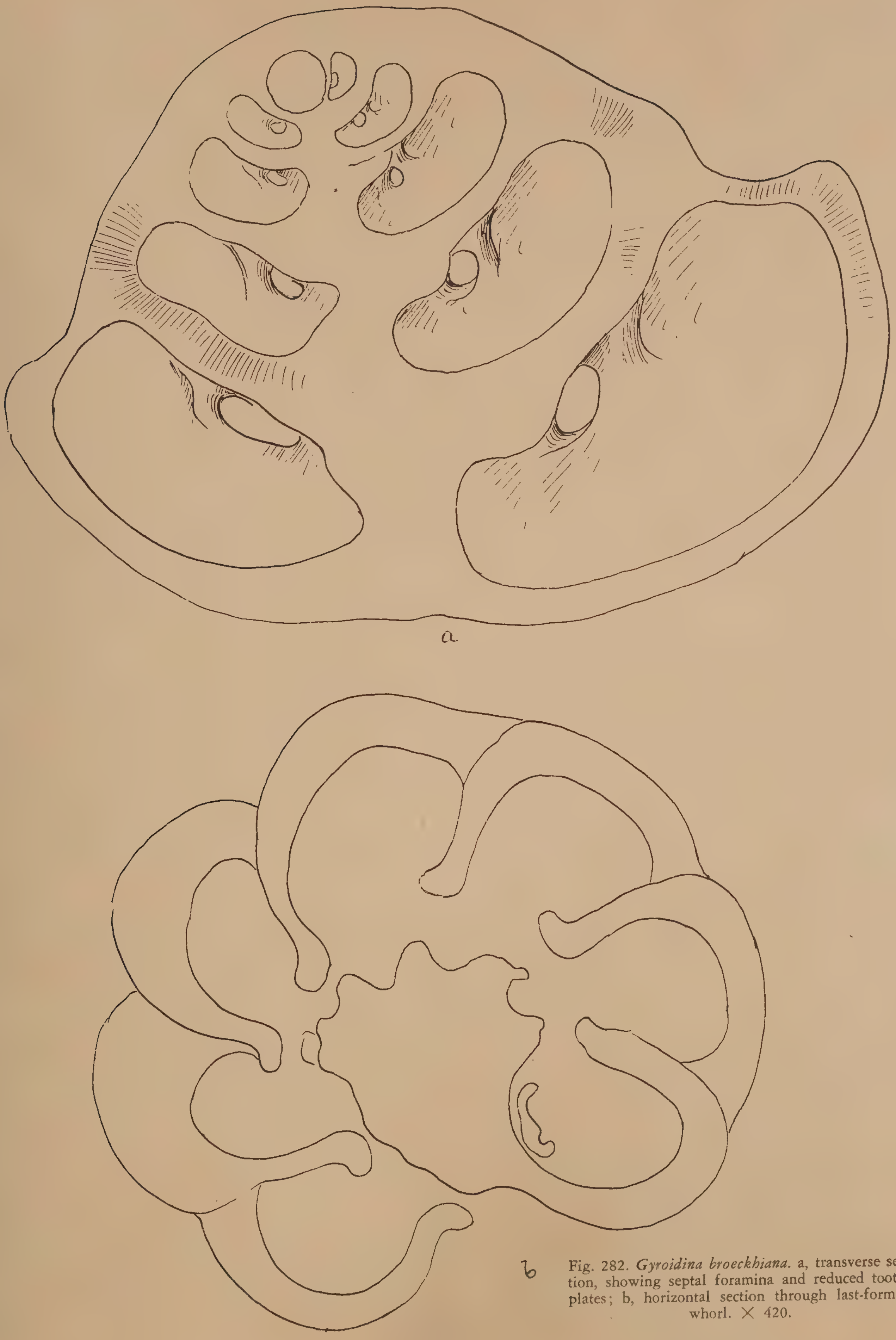


Fig. 282. *Gyroidina broeckhiana.* a, transverse section, showing septal foramina and reduced tooth-plates; b, horizontal section through last-formed whorl. × 420.

are provided with a protruding lip. The umbilicus, totally filled up with shell-material, points to real *Eponides.*

The species has been found at St.:

1° 52′ S., 99° 36′ E., depth 683 fathoms;
2° 17′ S., 99° 56′ E., „ 613 „ ;
2° 2′ S., 99° 48′ E., „ 460 „ .

Genus **Laticarinina**

This genus has been characterised by Cushman as allied to the *Cibicidae.* But a closer study of the test shows, that it has nothing to do with *Cibicides.* In *Cibicides* no toothplate can be traced; in *Cibicides* the walls always show coarse pores, whereas those of *Laticarinina* always are extremely fine ones; in *Laticarinina* the toothplate is nearly identical with that of *Epistomina,* in which also fine pores are found, but the toothplate forms here a broad keel.

The genus has been traced down to the Miocene, so it is a young genus. It may have derived from *Epistomina,* but in the Miocene already real *Cibicides* with coarse pores had developed in many species, so that it would be impossible, that *Laticarinina* derived from that genus, as always species with fine pores preceed those with coarser pores. But, as both *Epistomina* and *Laticarinina* show fine pores, it would be probable, that *Laticarinina* developed from some *Epistomina* from the *elegans*-group, which is not yet specialized. See for fossil species of *Laticarinina* Cushman, Contr. Cushman Lab., Vol. 18, pt. 4, 1942, p. 14-20.

Laticarinina pauperata (Parker et Jones)
(Figs. 283-284)

This species, first mentioned by Parker and Jones (Phil. Trans. Vol. 155, 1865, p. 395, pl. 16, fig. 50, 51), and given under the name of *Pulvinulina pauperata* by H. B. Brady in his Challenger-Report (Vol. 9, 1884, p. 696, pl. 104, figs. 3-11), was called by Cushman *Pellatispira pauperata* (Bull. Scripps Inst. Ocean., Techn. Ser., vol. 1, 1927, p. 176, pl. 6, fig. 13) and, after the publication by Galloway and Wissler (Journ. Pal. vol. 1, 1927-28, p. 193) it has been known in literature as *Laticarinata pauperata* (Parker et Jones).

Galloway and Wissler proposed it to be placed in the group of the *Lagenidae.* The very fine perforation of the test, the carina around the margin, easily lead to this proposition, as in the group of the *Cristellarinae* likewise these features are found. But the real structure of the carina, together with the total aberrant aperture show, that this place is very doubtful. Therefore Cushman tried to carry on a resemblance of this genus to the genus *Cibicides,* giving a description which leads in that direction (1931, U.S. Nat. Mus., Bull. 104, pt. 8, p. 113: aperture on the periphery or even on the ventral side as in *Cibicides,* later on the margin on the dorsal side). But the aperture never occurs on the dorsal side, as sections showed me.

The species occurred in many specimens at a single station, 2° 58′ S., 99° 47′ E., at a depth of 928 fathoms, with a bottom temperature of 3,8° C.

The carina, and this is a very remarkable fact, is not limited to the outer margin of the chambers, but continues into the chamber, running towards the vicinity of the former aperture. Thus its situation strongly suggests a toothplate, the more, as the aperture is formed as that of all apertures of the *Epistomina*-group, being a loop-like opening, with one border at which the toothplate adheres, protruding more than the other one. The toothplate surrounds the aperture at one side, and is melting together with the surrounding brim of the aperture. It is always found dorsally to this aperture, even in the first chambers. The toothplate is formed before the chamber itself is formed, just as in *Lamarckina,* and forms a flat, hyaline plate before the aperture, dorsally from it. Then it runs backward along the margin, adhering to the foregoing toothplate, and thus forming the broad hyaline carina. Always the aperture is found ventrally to the toothplate, as in *Epistomina.* But, while in *Epistomina* the broad toothplate does not project from the mouth, and forms on the contrary the so-called secundary aperture at the margin, the toothplate in *Laticarinina* runs back along the margin, to form the hyaline carina. In young tests the part of the toothplate which is found in the chamber itself is very small, possibly indicating that this part is much reduced and that the marginal outer part is here more strongly developed in the genus.

Laticarinina thus is very closely allied to *Epistomina, Lamarckina* and *Ceratobulimina,* as is shown by the very fine pores (unknown in real *Cibicides*), the typical toothplate, the few chambers, at least in the megalospheric form, the loop-shaped mouth, the forming of a ventral and dorsal part in the chambers by means of the toothplate, and the porcelaneous habitus of the chamberwalls themselves. I have suggested that *Laticarinina* should derive from *Epistomina.* It may be, of course, that the genus *Laticarinina* is the more primitive one, and in that case the outer part of the toothplate in *Epistomina* is reduced, forming the longitudinal rim, known as secundary foramen in *Epistomina.* Both forms, however, are very closely allied.

Description of *Laticarinina pauperata* (Parker et Jones).

Test coiled in a very plane cone, consisting of relatively few chambers, especially in the megalospheric generations. Walls of chambers somewhat porcelaneous, with very fine pores. Chambers on the dorsal side flat, on the ventral one more inflated. Aperture loop-shaped, with a dorsally higher border, from which a hyaline and thin, flat toothplate emerges, running first forward, then backward along the margin, and attaching itself with a fine suture to that of the former chamber thus forming a hyaline, broad carina along the margin. The toothplate afterward is involved in the next chamber, dividing this chamber partially into a dorsal and a ventral part, in which part the aperture of the former chamber opens. Walls in the outer chambers thin, but in the first chambers thickened.

Diameter of outgrown shells of the A_2-generation (the only one which was found in the sample) up to 1,35 mm.

A somewhat more detailed study of the species was given by Cushman (The structure and development of *Laticarinina pauperata* (Parker et Jones); Contr. Cushman Lab., Vol 17, pt. 4, 1941, p. 103-105). On p. 104 he says:

"A peculiarity of *Laticarinina,* differing from allied genera is the fact, that the chambers are in two portions: a larger ventral portion which on the proximal side extends back over the keel of the previous whorl, and a smaller dorsal portion flattened and extending back only to the periphery of the previous keel. The two portions are separated from each other by a thin plate representing a continuation of the keel but having an elongate sinus extending backward from about the middle of the chamber as shown at s in fig. 12a."

Cushman thus saw the toothplate, but he did not interpret it in the right way; he mentions, that it forms a continuation of the keel, while he ought to have described it as a toothplate, continuating in a keel at the margin.

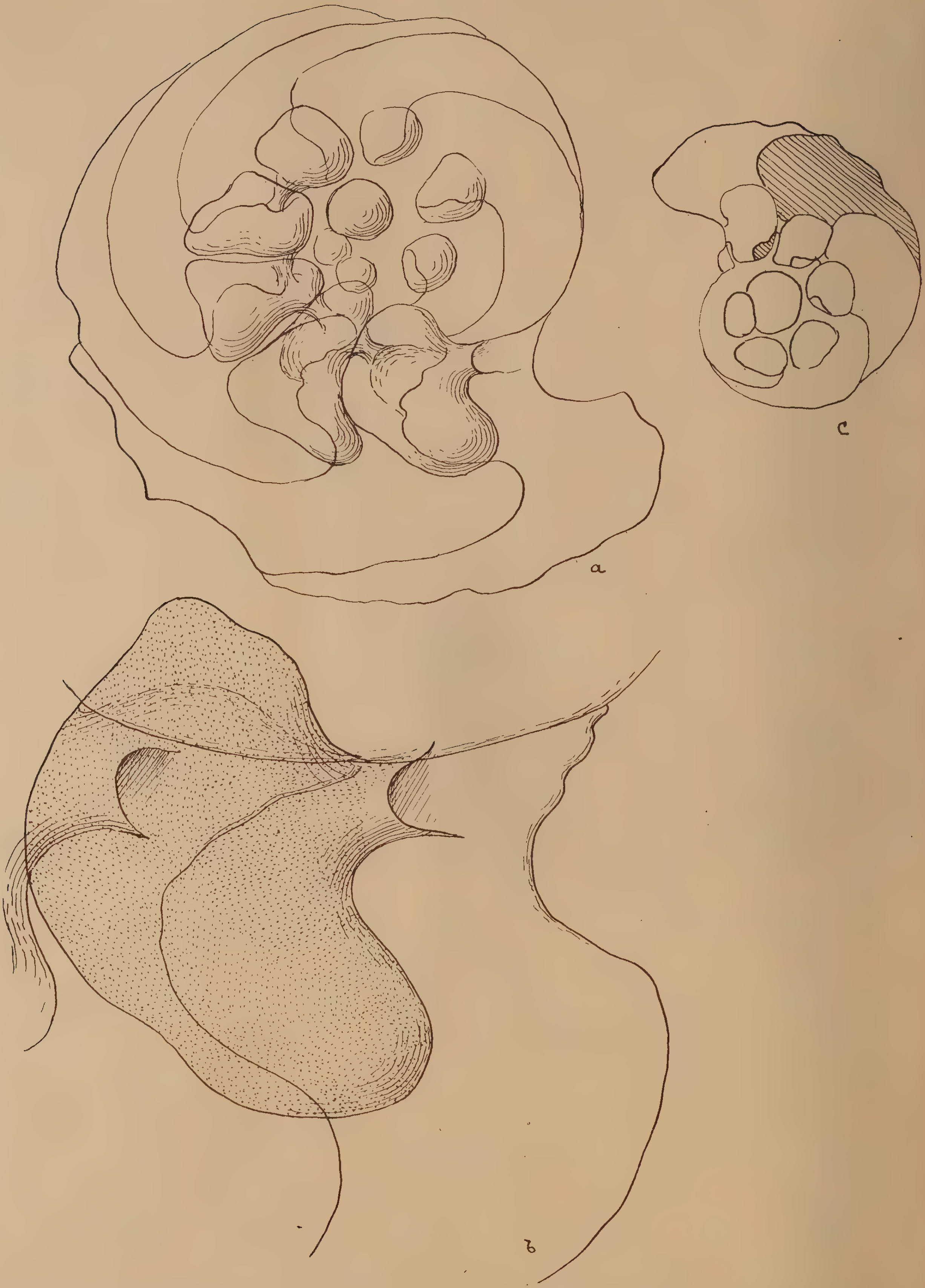


Fig. 283. *Laticarinina pauperata.* a. total megalospheric specimen, seen from ventral side, showing toothplates running through the chambers and forming the carina; b. same specimen, last-formed chamber; the smaller dorsal lobe at the other side of the carina of former whorl is seen too. a. × 87; b. × 420; c. young specimen, showing that in the first chambers the inner part of the toothplate is very small; × 87.

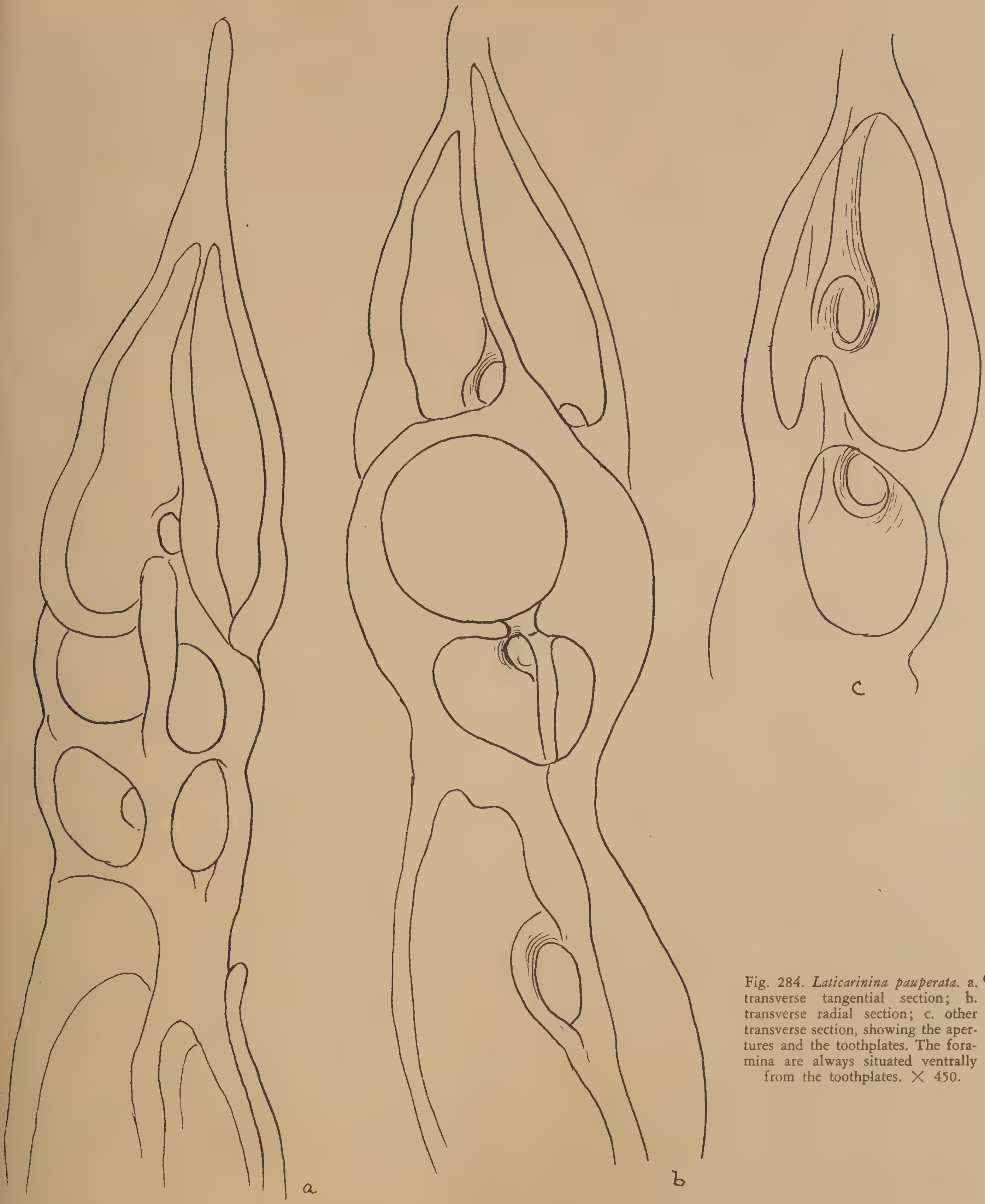


Fig. 284. *Laticarinina pauperata.* a. transverse tangential section; b. transverse radial section; c. other transverse section, showing the apertures and the toothplates. The foramina are always situated ventrally from the toothplates. × 450.

SUB-ORDO DEUTEROFORAMINATA

This sub-ordo shows in its more primitive forms a well developed toothplate, and the typical arrangement of the chambers is a coiled spiral. In its primitive groups it shows fine pores, all over the surface, but often parts of the test are hyaline and without pores; those parts often are formed by the toothplate, as is the case in the poreless parts of *Buliminella,* to which the ancestors of this sub-ordo are closely allied.

In a large group the toothplate extends along the margin of the test, thus forming a marginal hyaline part of the wall (*Marginolamellidae*).

More recent species in several groups develop out of the fine pores coarser ones, by a thickening of the walls around groups of fine pores; those secundary pores, in the bottom of which the fine pores often are still visible, I call here deuteropores, whereas the fine pores are called protopores.

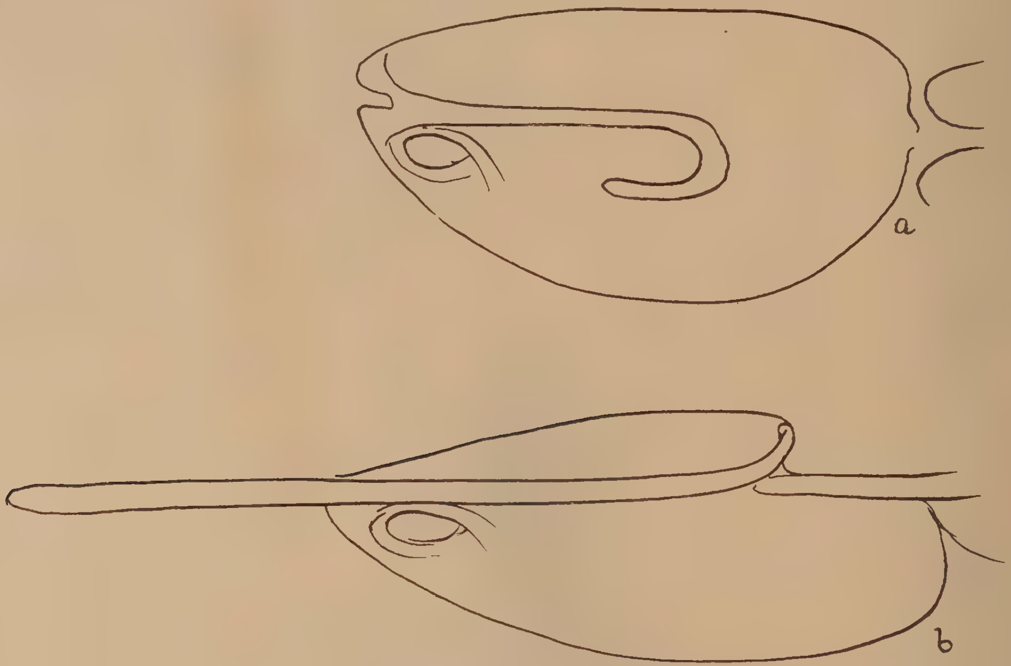


Fig. 285. *Laticarinina pauperata.* a. schematical section through a chamber of *Epistomina;* b. schematical section through a chamber of *Laticarinina.*

In primitive species two kinds of apertures are present, the protoforamen, to the dorsal or marginal side of which the toothplate is attached, and the deuteroforamen which is a newly developed aperture. Often only one aperture is found in more primitive forms, such as *Conorbis.* But in many later species the protoforamen is closed, and often obliterated. The deuteroforamen is present mostly as a typical ventral slit at the suture of the last-formed chamber. This slit in primitive forms runs along the middle of that suture, and may have developed a ventral lip which, in some forms, is developed by the toothplate in all those cases, in which this toothplate forms a more or less developed marginal hyaline part of the wall. This lip even may reach the umbilical hollow, as in all those forms, in which the aperture opens into this hollow, as in *Globotruncana* and in *Gavelinella.* But, in reality it is not the aperture (foramen) itself which opens into the umbilicus, but its lengthening, the hyaline lip (*Streblus, Neoconorbina*).

The hollow formed by the protoforamen, and open in the genus *Conorbis,* in some cases is closed by part of the toothplate (*Asterigerinata*) or is closed by a special protoporous plate, like the additional foramina of *Robertinoides*. This is the case in *Reinholdella* from the Jurassic and in *Asterigerina,* its descendant. This hollow is partly closed by irregular knobs of secondary chalk in the genus *Streblus* which seems to have derived directly from *Conorbis*. This protoforamen forms in *Streblus* the "ventral foramina", which in higher developed genera, such as *Rotalia,* give rise to a complicated ventral canalsystem.

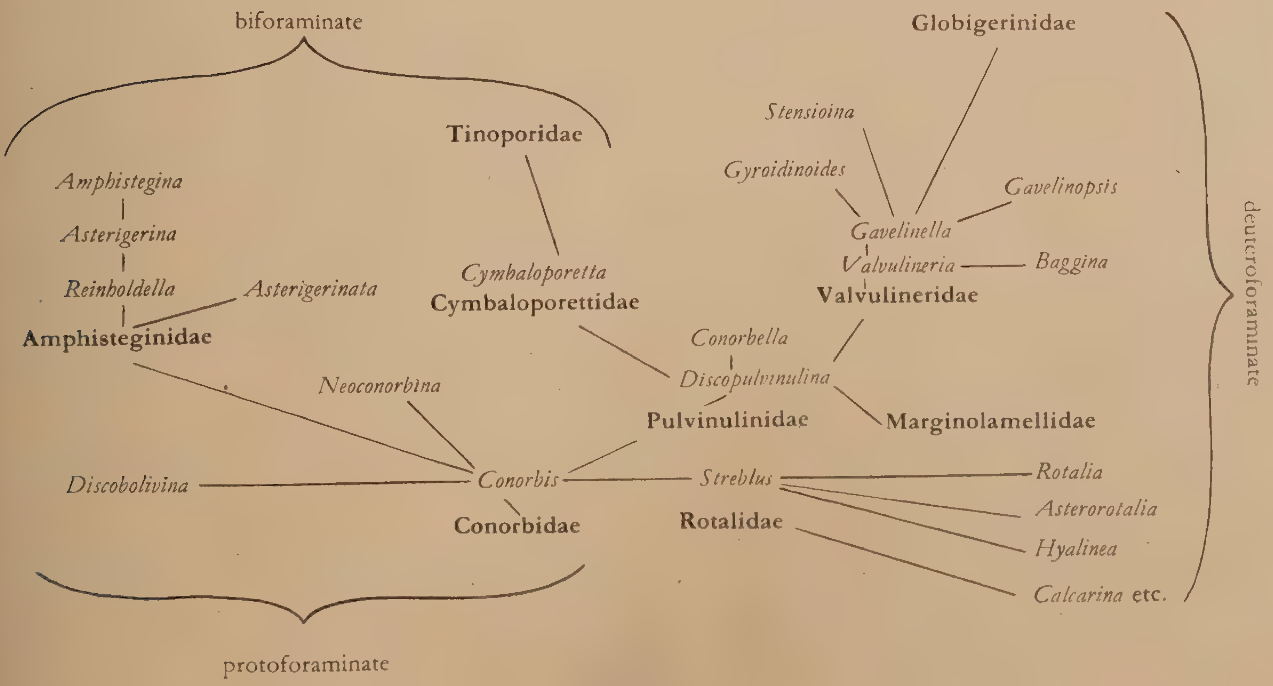
In *Discobolivina* the deuteroforamen has not developed, and the protoforamen, situated as in *Conorbis,* at the basal wall, forms also the septal foramen. In these forms the toothplate has maintained its pillarlike and vertical shape, as in *Conorbis*.

In some groups the dorsal walls of the chambers often are lacking protopores, as in the genera *Gavelinella* and *Gavelinopsis*. In *Neoconorbina* in primitive species protopores are found, whereas in more recent species deuteropores have developed, especially at the ventral walls.

In all those genera, in which the deuteroforamen has been developed, this foramen, or part of it, forms also the septal foramen, when a new chamber is added. This septal foramen in some cases, as in *Asterigerina,* is formed by the total deuteroforamen, but in many species and genera only part of the deuteroforamen (the aperture) forms the septal foramen. This is due to the fact that, as has already been demonstrated, only part of the so-called aperture is the real deuteroforamen, whereas in many cases, in which a ventral lip is formed by the reduced toothplate, only the marginal part of the ventral opening is the real deuteroforamen, and the umbilical part is nothing but the opening, formed by the elongation of the ventral border of the deuteroforamen, the lip. This part later on may remain open, as is the case in the later chambers of *Globotruncana* and *Globorotalia,* or in *Gavelinella* and *Gyroidinoides,* but in most cases it is closed by the ventral wall of the next chamber, so that a septal foramen, only opening in this next chamber, is formed.

Description of the genera and scheme of their relationship:

Sub-ordo **DEUTEROFORAMINATA**


biforaminate
Globigerinidae
Stensioina
Tinoporidae
Gyroidinoides
Gavelinopsis
Amphistegina
Asterigerina
Gavelinella
Valvulineria
Baggina
Reinholdella
Asterigerinata
Cymbaloporetta
Cymbaloporettidae
Valvulineridae
Amphisteginidae
Conorbella
Discopulvinulina
Neoconorbina
Pulvinulinidae
Marginolamellidae
Discobolivina
Conorbis
Streblus
Rotalia
Asterorotalia
Conorbidae
Rotalidae
Hyalinea
Calcarina etc.
deuteroforaminate
protoforaminate

In the *Protoforaminata* the protoforamen in the more primitive forms is situated as in *Bolivina* or *Virgulina,* viz. axially. In the *Biforaminata* the protoforamen is situated marginally. This difference is of very great importance, as it gives rise to quite different orientation of the whole test. In the *Deuteroforaminata* the test, when seen with the proloculus on top, develops axially, according to the place of the protoforamen; so the tests will have the tendency to possess a flattened base, whereas in the *Biforaminata* the test tries to become more or less inflated at its base, as the protoforamen is not basal or axial.

The most primitive group is that of the *Conorbidae,* in which the genera *Conorbis* and *Discobolivina* have been placed; they show but a single foramen which is without doubt a protoforamen, as the toothplate is attached to one of its borders (the proximal one, in respect to the place of the proloculus). The test shows a flattened basal side and is more or less conical in all species. The protoforamen is situated axially, and thus it is placed at the base, the septal foramina, descending from the protoforamen, being also placed axially and basal in respect to the chambers.

Genus *Conorbis.* Test conical, closely coiled. Walls opaque, yellowish, polished or ornamented with ridges and costae, pores very fine protopores. Aperture axial and basal at the suture, a loop-shaped opening, with a pillarlike toothplate, running from the former foramen to the next one, with an attached part attached to axial border. Jurassic and Cretaceous up to Recent.

Genus *Discobolivina.* In this genus are incorporated the former genera *Patellina, Patellinella* and *Patellinoides,* as they show only specific differences. Here the chambers become so long, that they tend to form a biserial spiral, thus reminding of the status of *Bolivina.* All characters are those of *Conorbis,* but here the walls have become hyaline. In *Discobolivina corrugata* and some more species the toothplate forms partial septa in the chamber. So it may be, that one will be inclined to create for those somewhat more complicated species a different generic name, *Patellina.* In that case there is a family, the *Discobolivinidae.*

The biforaminate *Deuteroforaminata* have developed a second foramen together with the protoforamen. This deuteroforamen originally is found more marginally to the protoforamen, and sutural. In many forms in this group the protoforamen is closed, often by a porous plate, resembling the chamberwall in most points. In other advanced groups the protoforamen remains open while the toothplate has been more or less obliterated. Often the toothplate forms an outer poreless lip, situated between the two open foramina. This lip may partially cover the umbilical hole. In those forms, in which the protoforamen is closed by a porous plate, the cavity in the protoforamen widens into a chamberlet, intercalated between the normal chamberparts (supplementary chambers).

Genus *Neoconorbina.* Conical tests, often with concave base. Chambers at last very long, often forming more than the half of the circumference. The basal suture shows the deuteroforamen often near to the margin, followed backwards by a more or less developed lip, which lip is ending at the protoforamen; in many cases there is no typical bordering between proto- and deuteroforamen; toothplate more or less reduced. In geologically later forms deuteropores are a rule. In most species walls opaque, but not yellowish. Tertiary to recent.

It is a matter of taste, whether one should place the genus *Neoconorbina* within the *Conorbidae* or not.

In the *Amphisteginidae* the opening of the protoforamen always is closed by a porous plate. The tests are always more or less conical, but the forming of supplementary chamberlets often makes the ventral side more bulky. Always protopores.

Genus *Reinholdella.* Conical, with flat basal side. Protoforamen always in the middle of the suture between the centre and the periphery, and more or less parallel to the periphery. Deuteroforamen at the opposite part of the ventral suture, small. Protoforamen in older chambers covered by a porous plate, but the hollow of the protoforamen not clearly separated from the lumen of the chamber, as the toothplate is not yet horizontally placed but more in the direction, found in the *Conorbidae,* from which the genus undoubtedly is deriving. It has been named by Brotzen *Reinholdella.* Jurassic.

Genus *Asterigerina.* Deriving from *Reinholdella,* differing from it by the horizontal position of the toothplate and consequently the enlarging of the protoforaminal hollow, now becoming a "supplementary chamberlet". In many ancient forms (Miocene-Recent) the conical form of the test is maintained, but often the supplementary chambers become more or less bulky, especially in tertiary forms. Megalospheric proloculus always connected with the second chamber, forming a bilocular embryo. Protopores. Always pustules around the deuteroforamen. Cretaceous (?), Tertiary-Recent.

Genus *Amphistegina.* In the young very much resembling *Asterigerina;* older tests differ as the dorsal parts of the chambers overlap the dorsal older coils, often by somewhat irregular prolongations. Deuteroforamen very narrow and always surrounded by pustules, as in *Asterigerina.* Tests often biconvex and nearly planospirally built. Tertiary-Recent.

Genus *Asterigerinata.* Protoforamen covered by a projecting part of the toothplate, and closed by it in older chambers. Deuteroforamen ventral. Proto- and deuteropores, toothplatepores. A single recent species known, *Asterigerinata mamella.*

Among the biforaminate groups of the *Deuteroforaminata,* in the most primitive genus *Discopulvinulina* the status of the foramina is that of *Neoconorbina,* but for the fact, that in many species already a reduction of the protoforamen takes place. From *Discopulvinulina* a very important group has developed, in which the proto- and deuteroforamen are nearly equally important, while the protoforamen remains open. So this group has to be placed among the biforaminate *Deuteroforaminata,* though they descend from the basal group of the *Deuteroforaminata, Discopulvinulina.* This group encloses the families *Cymbaloporettidae* and *Tinoporidae.* The chamber in young specimens shows the structure of that of *Discopulvinulina,* but later on a contorsion of its axis takes place, so that the lip between proto- and deuteroforamen becomes situated axially, whereas both foramina are situated left and right to the chamber. Thus each chamber possesses two nearly equally sized foramina with, in the *Cymbaloporettidae,* a third opening under the lip, leading to the umbilical cavity. In the *Tinoporidae* the lip is closed and obliterated, so that the two foramina form the openings in the chamberwalls. In some higher specialised forms more openings may be added, while in the megalospheric forms the initial part shows the "raspberry-type".

Genus *Cymbaloporetta.* Initial part as in *Discopulvinulina*; later the chambers become contorted, and proto- and deuteroforamen are situated left and right to the chamber, whereas the lip forms a third opening leading into the umbilical cavity. In some forms the lip (offspring of the toothplate) forms bridges between the opposite chambers, closing the umbilical cavity. This bridge may even become inflated in some reproductive stages of development, as to form a "floating-chamber". In some species later chambers may have many openings along the sutures, deriving from the two foramina by dividing. Tertiary-Recent.

From the genus *Conorbis* have undoubtedly derived those genera, here gathered in the family of the *Rotalidae.* In this group *Streblus* is the more primitive genus. Here the protoforamen remains open, and is forming a primitive umbilical canalsystem, mostly opening at once into the outer world. The deuteroforamen in most cases is narrow. From this genus *Rotalia* has developed by the forming of a much larger canalsystem, whereas interlocular canals in the septal walls, which here often are double throughout, are added. In *Asterorotalia* the sutures are covered by porous plates, as in the *Amphisteginidae,* but these "chamberlets" open with a marginally placed aperture, which is not the case in *Amphisteginidae. Hyalinea* seems to have derived directly from *Streblus* in flattening the coiling spiral, so as to become nearly planospiral. The protoforamina remain open, and run through the walls into the ventral flattened umbilical cavity as usual.

Genus *Streblus.* Toothplate as in *Conorbis,* slightly reduced. Protoforamen ventral or umbilical, in older chambers partly closed by secondary chalk-knobs. Deuteroforamen covered by a ventral lip, at ventral suture. Protoforamen later giving rise to umbilical canalsystem, which here is not yet fully developed. Often a central chalk-knob in umbilical cavity. Protopores. Cretaceous-Recent.

Genus *Rotalia.* A more complicated *Streblus,* as interseptal canals are added to the umbilical canalsystem, by doubling up the septal chamberwalls. Tertiary-Recent.

Genus *Asterorotalia.* Elongate porous plates are covering the depressed sutures at the ventral side, closing the cavity between the chamber and the central umbilical knob; these secundary chamberlets are opening with a distinct pore near to the margin. Proto- or deuteropores. Tertiary-Recent.

Genus *Hyalinea.* Structure as in *Streblus,* but the spiral flattened, nearly plano-spiral. At ventral wall the protoforamina open into the flattened umbilical space. Protopores. Only a single species known, *Hyalinea baltica.*

The main group of the deuteroforaminate genera among the sub-ordo of the *Deuteroforaminata* derives from the family of the *Pulvinulinidae,* in which family are enclosed the mother-genus, *Discopulvinulina,* and the genus *Conorbella.*

In *Discopulvinulina* the variability between the species is very high, but the apertural conditions are restricted: a small, often nearly reduced protoforamen, with often reduced pillar-shaped toothplate; a more or less developed lip between proto- and deuteroforamen in the centre of the ventral suture, opening into the umbilical cavity more or less. The lip always is poreless; a deuteroforamen, often nearly marginal, and now clearly distinguishable from the protoforamen. In many forms the dorsal parts of the chambers overlap, thus forming tests which may have been confused with those of *Cibicides*; but their convex dorsal side in this case is confused with the convex ventral side of *Cibicides.* In some advanced species deuteropores are developed. Cretaceous-Recent.

Genus *Conorbella.* Protoforamen totally absent; deuteroforamen small and not basal. At ventral side always radiating ornamentation. More or less conical. Recent.

In the *Valvulineridae* the protoforamen is totally reduced, and thus the toothplate is absent too, but for the apertural lip; this lip plays a large part in systematics of this group. The family encloses the genera *Valvulineria, Gavelinella, Gavelinellopsis, Gyroidinoides, Stensioina.* As I have pointed out already, the groups, allied to *Anomalina-Cibicides* cannot have derived from *Valvulineria.* All these genera show very distinct characters. They cannot be allied to the *Marginolamellidae,* in which group I have gathered all those genera, having an axial lip, covering partially the umbilical region, and showing a clear, poreless margin, connected with the poreless part of the lip. They show features which connect them with the genus *Discopulvinulina,* but will be dealt with in another part of this paper. The *Globigerinidae* will not be treated in this paper.

Genus *Valvulineria.* Here the lip has become prominent, and covers the larger part of the umbilicus, without, however, closing it. Protopores cover most of the walls, dorsally and ventrally.

Genus *Gavelinella.* Often nearly planispiral, but always with a distinct ventral and dorsal side. At the dorsal side all chambers visible, at the ventral side the often large umbilical cavity partly covered by the apertural lips, opening into that cavity. In all real *Gavelinella* the dorsal side is poreless, only the ventral side shows pores. These pores in the older types (Lower-Cretaceous) are fine protopores, in later forms deuteropores may have developed. The genus *Gyroidinoides* shows nearly the same characters as *Gavelinella.* In recent *Gavelinopsis* the test shows a sharp difference between dorsal and ventral side, as the periphery is sharp. Here too the dorsal side is lacking pores, at least in the initial part. Often a central knob of secondary chalk is formed in the umbilical hollow; here too the apertural lips are opening into the ventral cavity.

Genus *Stensioina.* Most characters are those of *Gavelinella*: a poreless dorsal side, now ornamented by upraised sutures, and only pores, mostly deuteropores, at the ventral sides. Apertural lip opening into the ventral umbilical cavity, dorsal side often flattened. Upper-Cretaceous. The genus may have been confused wih ornamented *Cibicides.*

Genus *Baggina.* This genus is only slightly differing from *Valvulineria,* as the chambers here are much more inflated, so that the test often becomes nearly globular. The apertural lip is formed as in *Valvulineria,* but is often nearly closed at its axial border. It has often been placed in the neighbourhood of *Cancris,* but differs from that genus in the possession of a clear poreless margin and totally closed apertural lip over the umbilicus in the latter genus. *Cancris* has to be placed in the *Marginolamellidae* and not in the *Valvulineridae.*

The new family of the *Marginolamellidae,* which will not be analysed in this paper, as many species of it occur in the West-Indian region, so that I will deal with it in a paper about that region, enclose the genera *Globotruncana, Globorotalia,* and some allied genera, and *Cancris.*

Geographic distribution

Conorbis bradyi. Southern of Sumatra, western part.

Amphistegina radiata. All over the area. It was found by Cushman in many localities in the Philippines, but not in the eastern part of the Malayan Archipelago. I mentioned the stations in Siboga I.

Conorbella tabernacularis. A single specimen south of Sumatra. It was not mentioned by Cushman from the Philippines, so it may be restricted to the western area.

Discopulvinulina turbo. Only at Merak, western part.

Discopulvinulina pacifica. In the western part only. But I found it also south of Australia, so it occurs too in the Australian region.

Discopulvinulina bradyi. Western part, Merak.

Discopulvinulina hyalina. Western and eastern part, Australia.

Discopulvinulina pseudolobatula, Western part, Philippines.

Cymbaloporetta bulloides. Western part.

Cymbaloporetta squamosa. Western part.

Cymbaloporetta bradyi. Western part.

Discobolivina conica. New Zealand, Australia.

Discobolivina nitida. South of Sumatra, western part.
Discobolivina ambulacrata. South of Sumatra, western part.
Discobolivina inconspicua. In both areas, south of Sumatra and in the Savu Sea.
Neoconorbina marginata. Western part.
Neoconorbina pacifica. Merak, western part.
Streblus turgidus. Western part.
Hyalinea baltica. Both areas.
Asterorotalia pulchella. Both parts.
Gavelinellopsis praegeri. Both parts.

Most of the species have been found in the western part. From the genus *Discobolivina* the more primitive species, with rounded periphery, were found in the western, while those with a compressed test, *conica* and *inconspicua,* are found too in the eastern part. *Discopulvinulina pacifica* seems to exist in both areas, together with *D. hyalina, Gavelinellopsis praegeri* and *Hyalinea baltica.*

Genus **Conorbis** nov. gen.

I regard as real *Conorbis* all those species, which show following characteristics:

Test totally consisting of separate chambers, beginning with a globular proloculus. Test spirally coiled, more or less conical. Walls always with fine protopores. Ventral side mostly flattened or concave, dorsal side more or less conical and convex. Ventral walls always without radial ornamentation. Two apertures exist, a protoforamen, forming a typical distinct sling in the last-formed suture, and connected with a pillar-shaped toothplate, running to the dorsal roof of the chamber; and in some forms a deuteroforamen, axial to the protoforamen, consisting of a more or less widened slit at the suture, and covered by a more or less developed lip, often partly covering the umbilical hollow. The deuteroforamen or part of it forms the septal foramen, which in most cases is situated dorsally, and is rounded. It is consequently found distally from the toothplate in transverse sections. Typical from the Jurassic up to recent times.

To this genus belong, according to my investigations, without doubt the species *Conorbis mitra* nov. spec. from the Gault of the Netherlands, *Conorbis bradyi* from the Pacific, and *Conorbis advena* from the West-Indian regions. It may be, that several other recent species occur, but many species hitherto known as *Discorbis* should be placed in quite other genera.

The type of the genus is *Conorbis mitra* Hofker.

Conorbis mitra nov. spec.
(Fig. 286)

Test more or less conical, especially in adult forms, throughout trochoid. Ventral side flat. At first the chambers are spirally arranged, 6 chambers in a coil, later the chambers are longer, and tend to become two chambers in a coil. The ventral suture shows a distinct indentation at the aperture, which is an open slit at the ventral umbilical suture. At this indentation a distinct toothplate

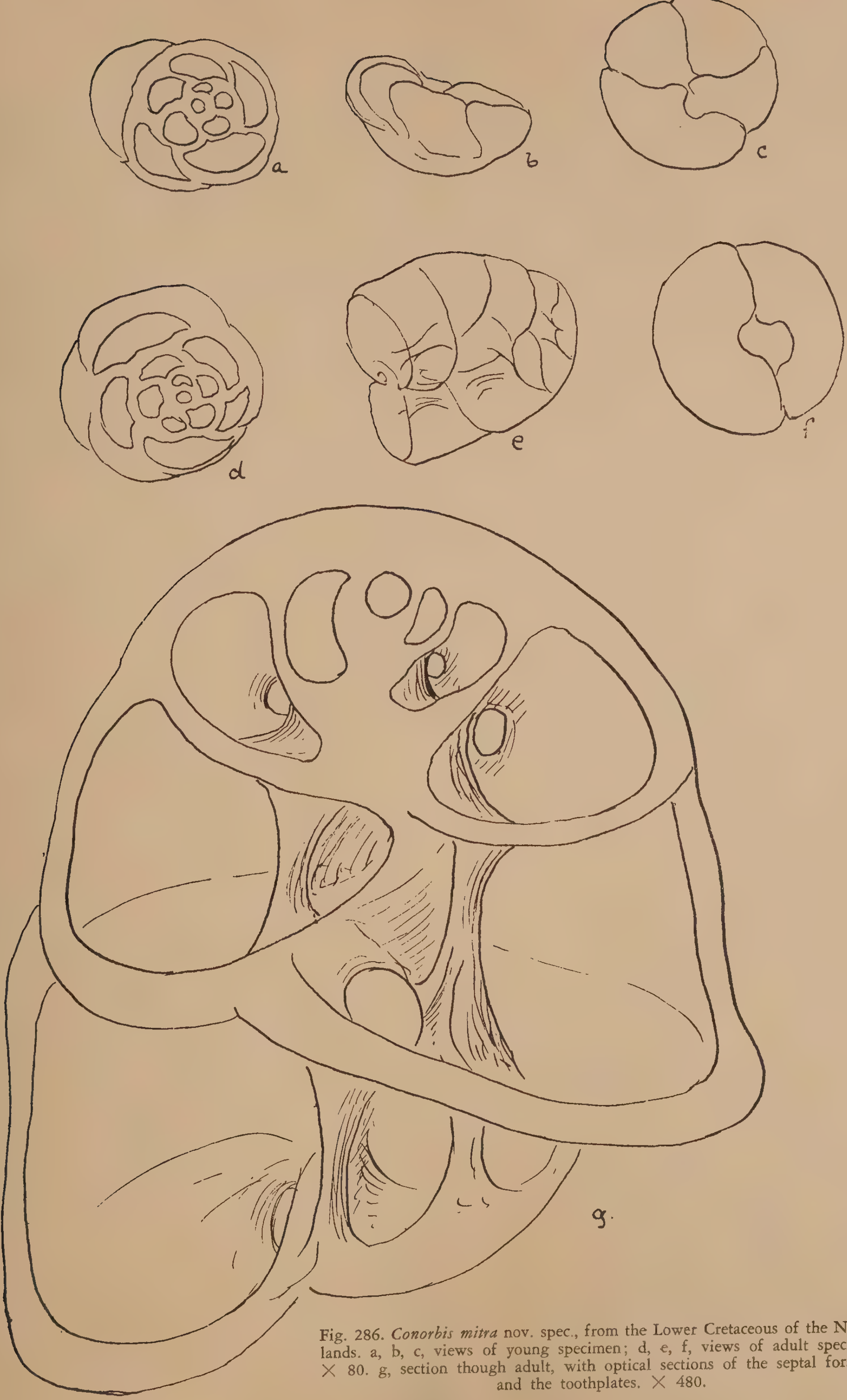


Fig. 286. *Conorbis mitra* nov. spec., from the Lower Cretaceous of the Netherlands. a, b, c, views of young specimen; d, e, f, views of adult specimen; × 80. g, section though adult, with optical sections of the septal foramina and the toothplates. × 480.

is attached, running from the formed aperture. It shows all the characteristics of the toothplates of *Discobolivina* in later chambers.

The walls are opaque, yellowish, provided with very fine pores, all over the walls.

The species points to the fact, that *Conorbis* with many characters of *Discobolivina* occurs in the Lower Cretaceous. But, as the pores are uniform and fine, this species is a primitive one, leading up to higher organised *Neoconorbina* (with two kinds of pores) and to *Discobolivina,* with the tendency of becoming biserially arranged.

The species occurred in several borings from the Rijksopsporing van Delfstoffen in the Netherlands, and was kindly afforded to me by the Geological Foundation of the Netherlands. The strata show to be the Lower Cretaceous (Gault). Several species occur in the Dogger.

It is remarkable for the fact, that younger tests show the typical characters of real *Conorbis,* having more than two chambers in the lastformed coil, a toothplate which is axial, and a foramen which is septal; but adult specimens show the later coils tending to become biserial, with the toothplate freely running through the chamber, and pillar-like, while the foramen becomes basal, as in real *Discobolivina.* This difference of the situation of the toothplate in the more initial chambers compared with that in the later chambers of adult specimens is a parallelism to what is found in the genus *Loxostoma* (in these sense in which it is used by American and modern authors); here too in the typical bolivine chambers with sutural aperture the toothplate is axial, whereas in the chambers with more terminal aperture it runs freely through the lumen of the chambers, without attached part. As the pores are totally protopores, one can be sure, that this species is an ancestral form, as in modern *Discobolivinae* there are deuteropores, except in *Patellina,* where only few pores have developed.

This species clearly shows, that the group of the *Discobolivinae* developed from real *Conorbis,* may be in the Jurassic.

Conorbis cf. *bradyi* Cushman
(Fig. 287)

Some rare specimens of a very typical species occurred at St. 2° 26′ S., 100° 0′ E., depth 222 fathoms. They are quite hyaline, dorsally convex, with a more or less distinctly keeled border which, at the ventral side is quite distinct and forms a hyaline margin. The ventral side is flattened with an open umbilicus and somewhat inflated chambers. At the dorsal side the sutures are distinct and somewhat thickened, obliquely onto the margin. At the ventral side they are nearly radiate, but highly curved, as the protoforamen is totally open (a typical characteristic for real *Conorbis*), forming a distinct and narrow string in the suture. The aperture, an arched opening in the middle of the suture, shows toward the umbilicus a heavy lip, which overlaps the umbilical hollow, ending, as in all real *Conorbis,* in the protoforamen. Here the toothplate can be seen through the wall with a clarifier, running upward down. Around the protoforamen and on the fringe of the lip the wall is totally poreless, further-on the walls are thickly covered on the ventral side with protopores, very fine, whereas on the dorsal side these fine pores are more scattered on the walls. The protoforamen devides the chamber, with its toothplate, in two parts, a proximal one and a distal one, which are, however, connecting by a large opening marginally from the toothplate.

Diameter up to 0,30 mm, thickness of test about 0,10 mm.

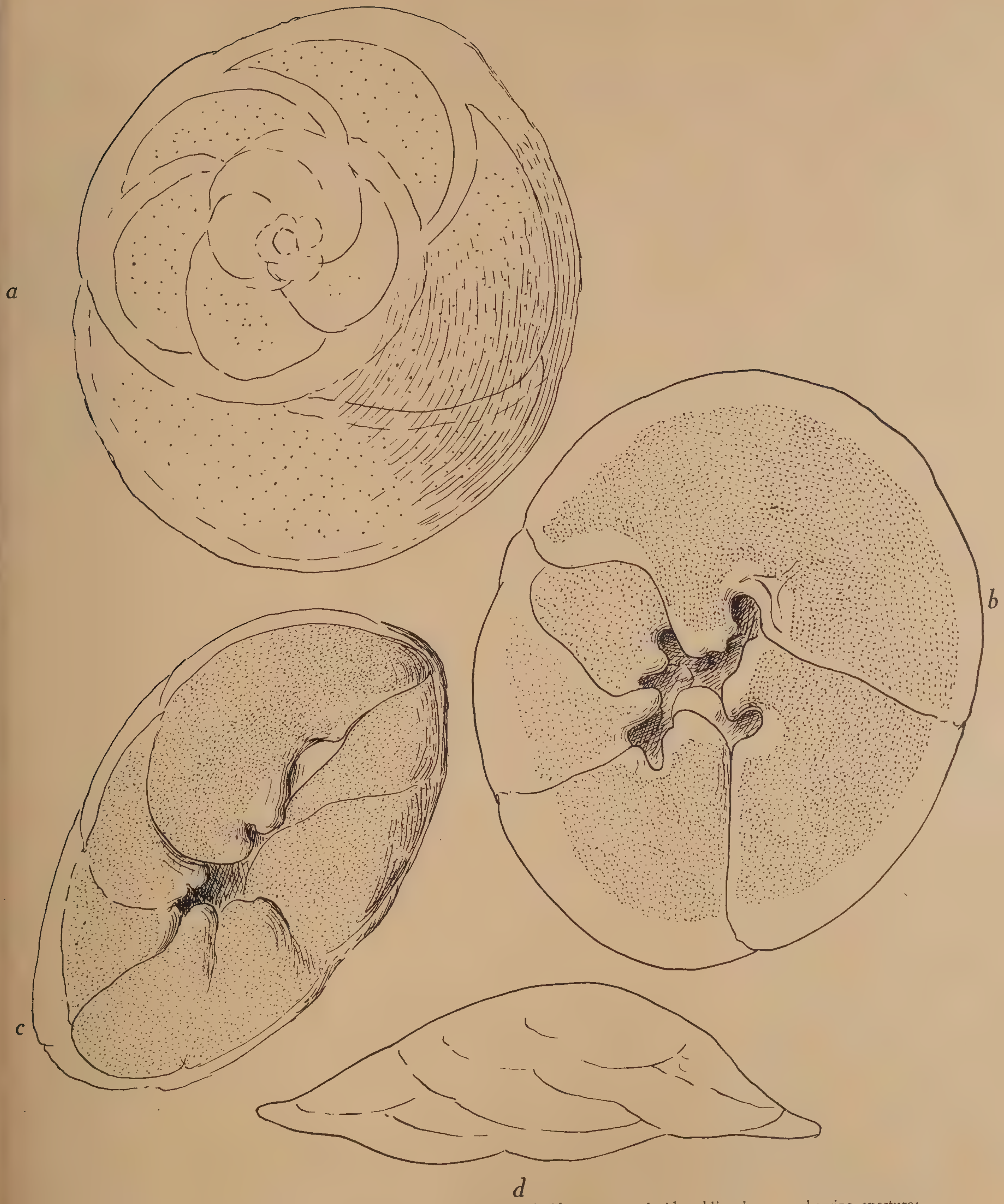


Fig. 287. *Conorbis* cf. *bradyi* Cushman. a. dorsal, b. ventral sides; c. ventral side, obliquely seen, showing aperture; d. sideview. × 420.

Genus **Discobolivina**, including the genera **Patellina**, **Patellinella** and **Patellinoides** (Figs. 289, 290)

The genus *Discobolivina,* as follows from the investigations I have made on several species, recent and fossil, can be described as follows:

Test conical, with flattened or concave base. Proloculus at top of test, followed directly by sets of chambers which are coiled spirally and, in primitive forms may give rise to more than two chambers in a whorl. Wall very smooth, very hyaline and in all well-known species without pores. Aperture at the axial part of ventral side of last-formed chamber, an arched slit, ending in a short curved part at the central side, at which the toothplate is attached. This plate is more or less pillar-shaped, at the axial part of the chamber, and running from the roof of the chamber towards its base. The toothplate may form in more complicated species partial partitions at the marginal side of the chambers.

I am sure, that those records which mention an undivided first part of the test, are erroneous ones, or that this character is due to the insufficient state of fossilisation. *Patellina* is not a primitive Rotalide genus, but a highly specialised one, as is indicated by the complicated form of the toothplate and lack of protopores. This toothplate moreover points undoubtedly to the genus *Conorbis,* in which similar toothplates are found. The absence of pores or the presence of deuteropores in some allied forms, points to the fact, that *Patellina* is a descendant of *Conorbis;* some species of *Conorbis*-like genera (*Discopulvinulina*) too show deuteropores as a typical advanced character.

Cushman (Contr. Cushman Lab. Form. Res., Vol. 16, p. 1, 1945, p. 11-17) has given a record of the genus.

He mentions *Patellina protea* Cushman et Waters from the Permian. This species, with its incomplete septa, cannot be a real *Patellina,* and may belong to some *Valvulina*-like species. *Patellina bradyana* Howchin is according to Cushman no *Patellina.*

Several species of *Patellina* have been recorded from the Cretaceous. Some of them may be a real *Patellina,* e.g. *Patellina subcretacea* Cushman et Alexander. But the description is very superficial, and a toothplate is not mentioned. In this species there is an undivided first part described, but this has to be checked. The typefigure shows that the chambers are not biserially arranged as in recent *Patellina. Patellina antiqua* Chapman cannot be a *Patellina,* as the arrangement of the partitions between the chambers is totally differing from those of *Patellina,* and as at the ventral side there is not the typical curved aperture. *Patellina trochiformis* Schacko cannot be a *Patellina,* as it has an undivided spire. *Patellina jonesi* Howchin from the Cretaceous of Australia needs further study, as Cushman says. *Patellina oolithica* Terquem cannot be a real *Patellina,* and *Patellina texana* is an *Orbitolina.*

From the Tertiary only two species are known: *Patellina dentata* Terquem, which may be a real *Patellina,* and *Patellina corrugata* Williamson, which is known too from recent localities. Cushman distinguishes *Patellina advena* from Pacific localities, which may be a different species from *P. corrugata. Patellina plicata* Terquem is a *Trochammina,* according to Cushman, and *P. campanaeformis* Brady "does not seem to be a true *Patellina*".

Thus there is strong indication, that the genus did not, as Cushman believes, occur in geological times earlier than the Cretaceous. Its toothplate indicates a strong relation with *Conorbis,* and it must have derived from that genus. As real *Conorbis* is known from the Jurassic time, this occurrence of *Patellina* agrees with this view.

The genera *Patellinella* and *Patellinoides* show no differences which are large enough to separate those genera from *Patellina.* They all show the typical more or less developed spiral arrangement of the first chambers, at least in some species in the microspheric form, rapidly becoming biserial. Their walls are always hyaline, without protopores, but in some species with scattered deuteropores. All show the typical pillar-like toothplate, except so-called *"Textularia" inconspicua,* in which the toothplate is more or less reduced.

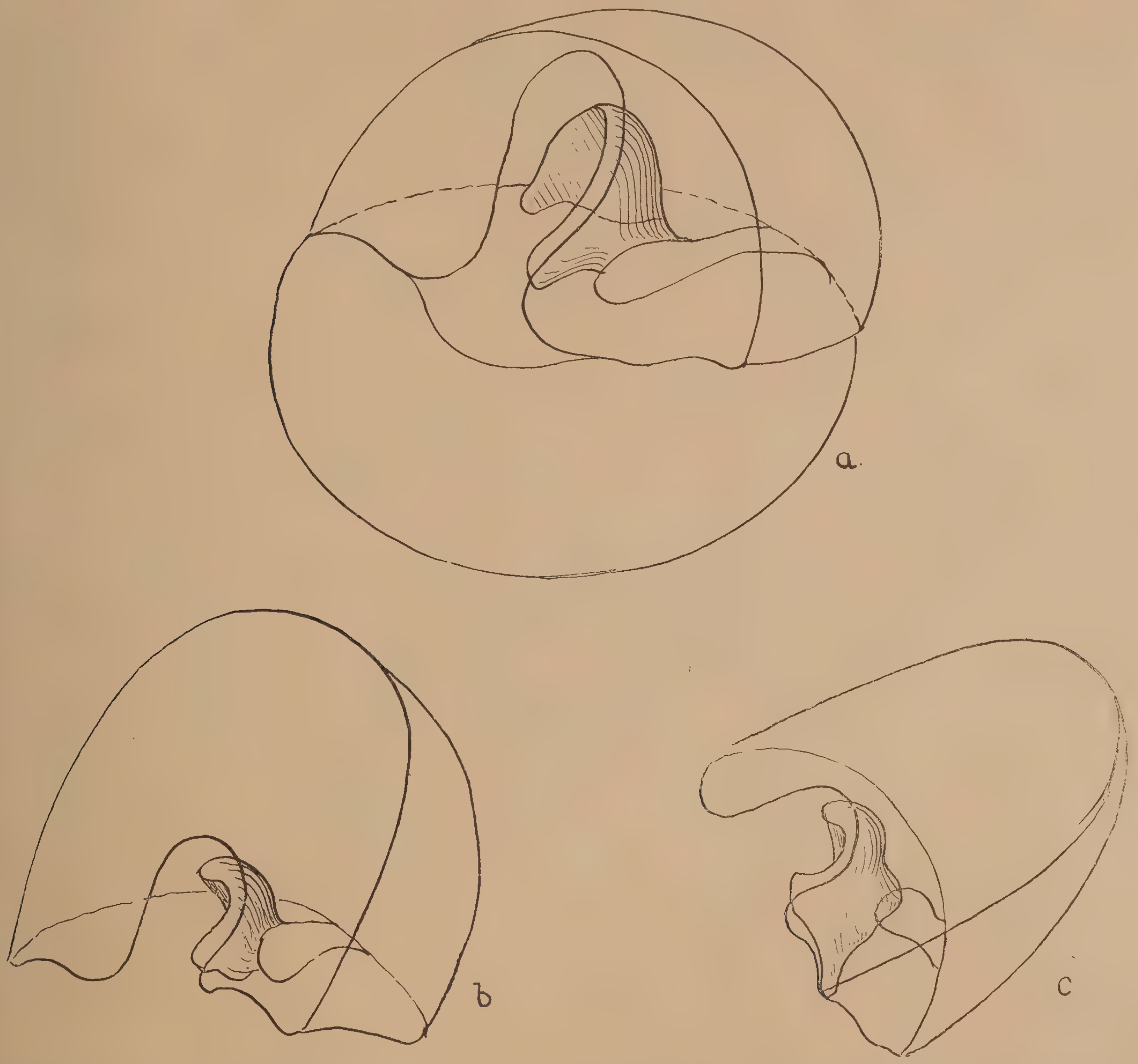


Fig. 288. a. Normal bolivine endchamber with normal toothplate, consisting of attached part, folded part and free part; b. The free part begins to reduce, the chamber capsizes backward; c. the toothplate enlarges in respect to its attached part, the chamber cants once more; b. is the situation, found in *Discobolivina inconspicua,* c. in *Disc. ambulacrata.*

All these typical similar generic characteristics enable us to deduct that *Patellina, Patellinella* and *Patellinoides* belong to a single genus. As, however, this genus is mainly characterised by a feature which has not been mentioned hitherto, when describing these three genera, I propose to gather these three genera in a new genus, *Discobolivina.*

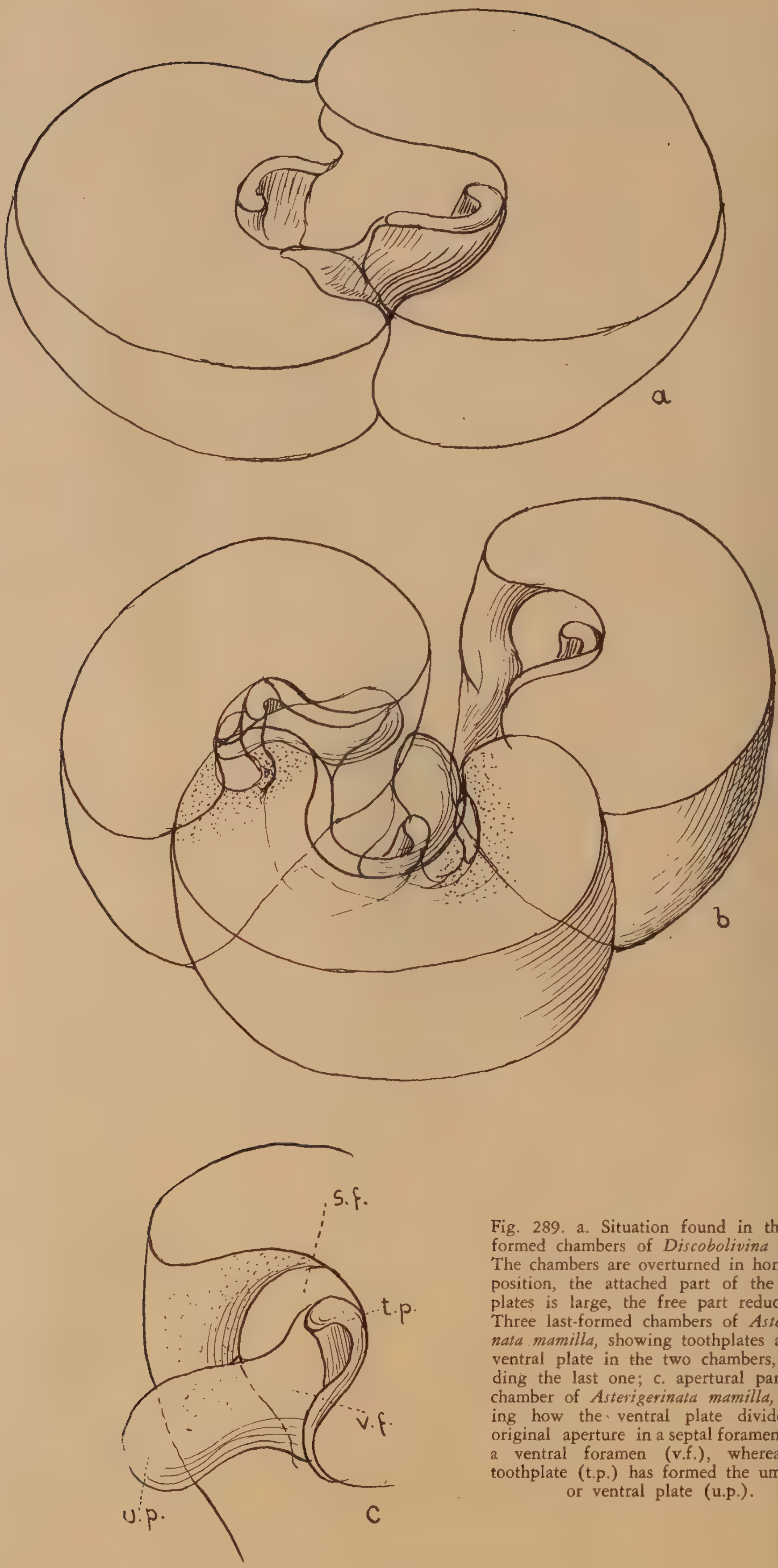


Fig. 289. a. Situation found in the last-formed chambers of *Discobolivina conica.* The chambers are overturned in horizontal position, the attached part of the toothplates is large, the free part reduced; b. Three last-formed chambers of *Asterigerinata mamilla,* showing toothplates and the ventral plate in the two chambers, preceding the last one; c. apertural part of a chamber of *Asterigerinata mamilla,* showing how the ventral plate divides the original aperture in a septal foramen (s.f.), a ventral foramen (v.f.), whereas the toothplate (t.p.) has formed the umbilical or ventral plate (u.p.).

Discobolivina conica Heron-Allen and Earland
(Figs. 290-292)

This very interesting species occurred in abundance at Little Barrier Island, New Zealand, depth 30 fathoms, from the Mortensen-Collection of his Pacific Expedition 1914-1916.

The test resembles that of *Discobolivina inconspicua,* but for its much more rounded apertural face and the thicker walls, whereas the sutures are not limbate but smooth, though hyaline, and

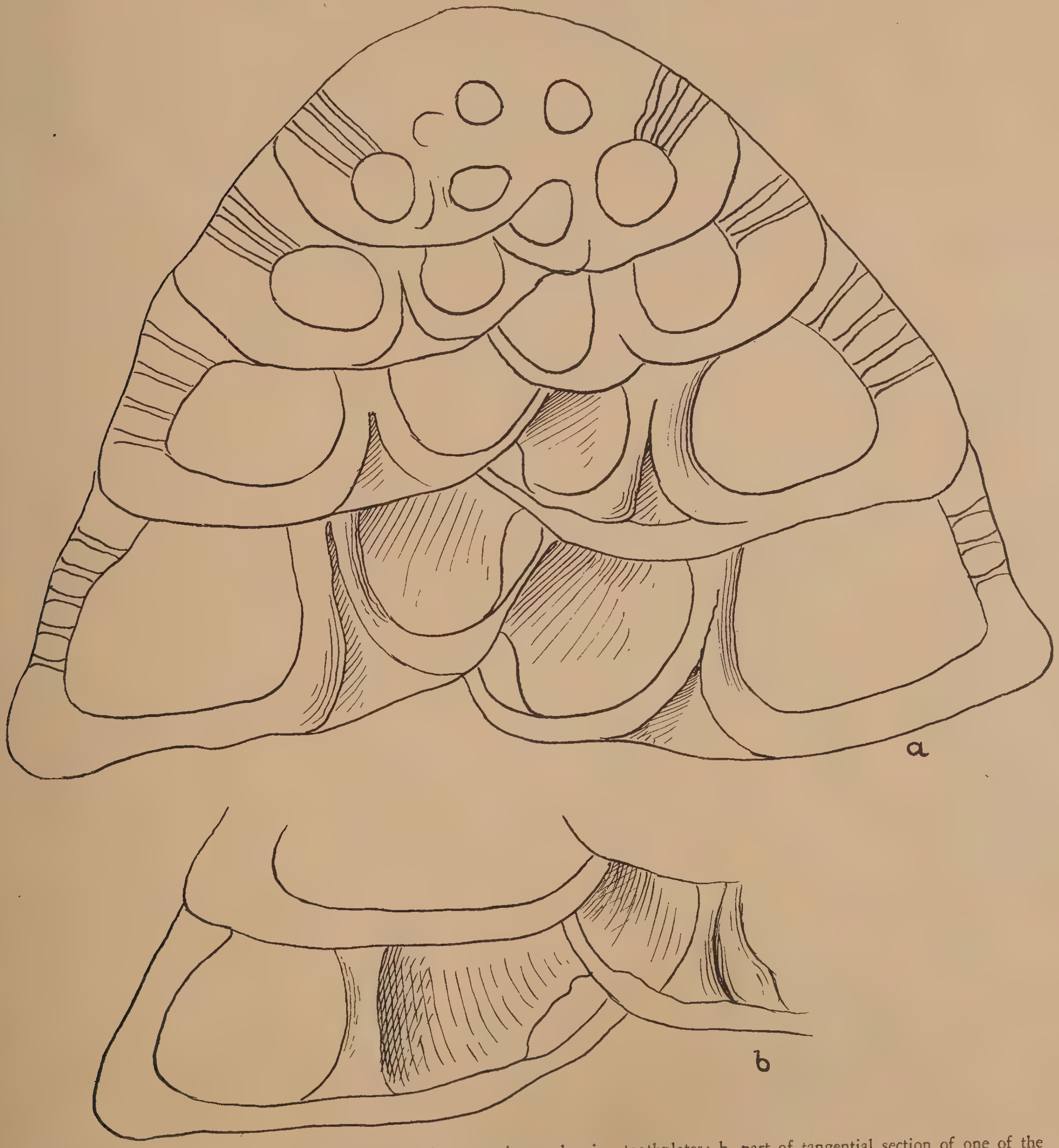


Fig. 290. *Discobolivina conica.* a. Section through large specimen, showing toothplates; b. part of tangential section of one of the lastformed chambers, showing details of toothplate; × 630.

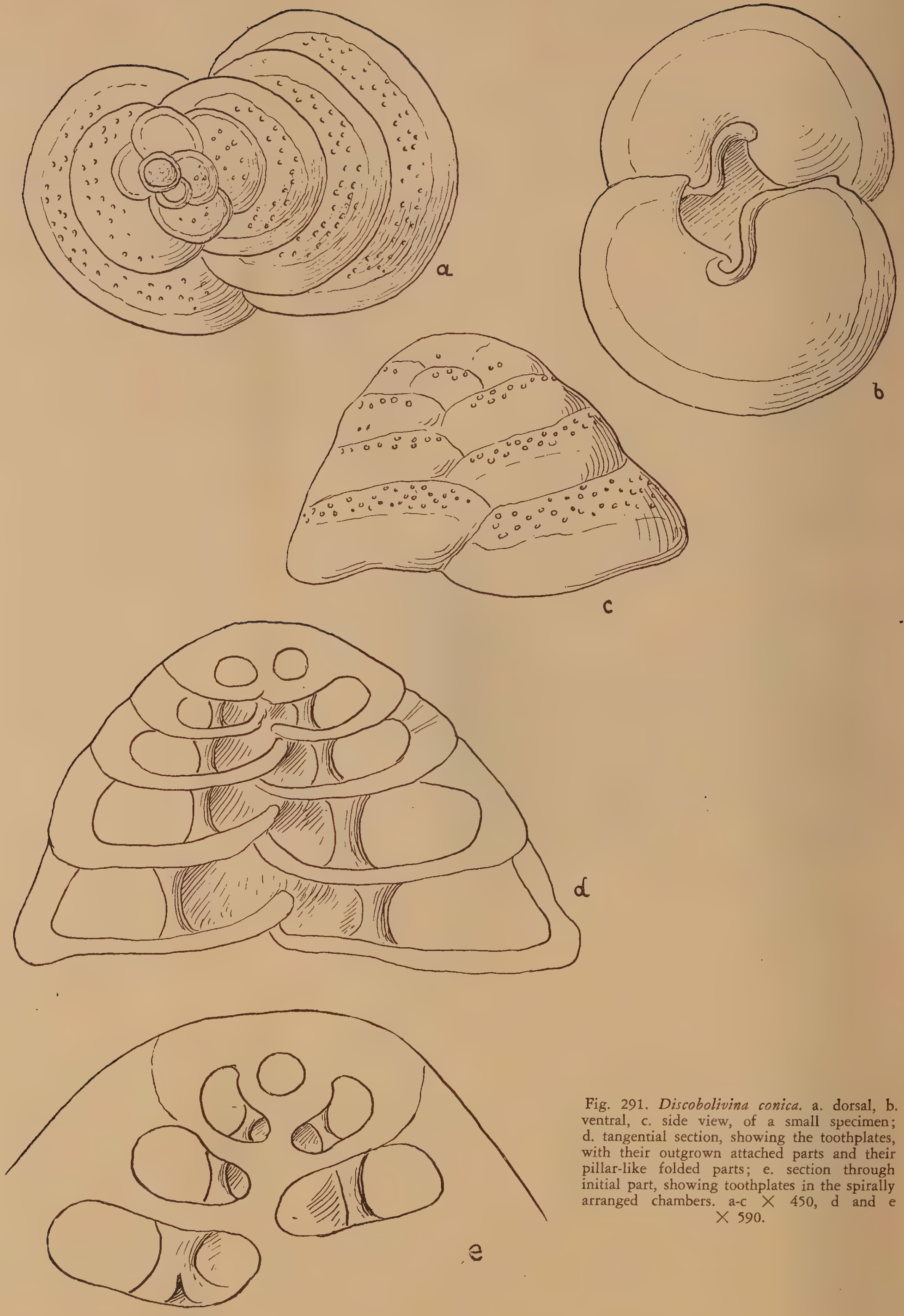


Fig. 291. *Discobolivina conica.* a. dorsal, b. ventral, c. side view, of a small specimen; d. tangential section, showing the toothplates, with their outgrown attached parts and their pillar-like folded parts; e. section through initial part, showing toothplates in the spirally arranged chambers. a-c × 450, d and e × 590.

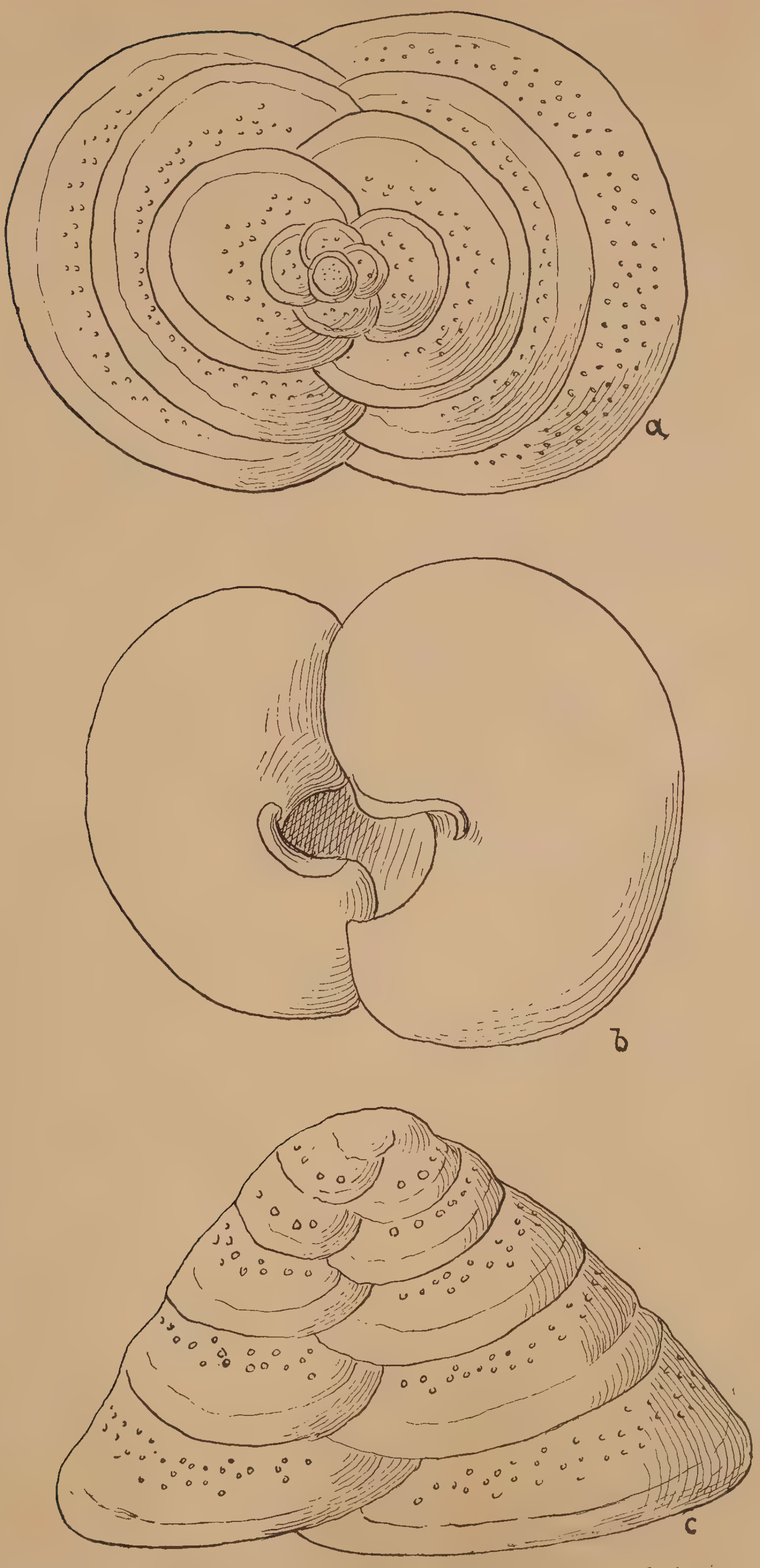


Fig. 292. *Discobolivina conica.* a. dorsal, b. ventral and c. side-view of a large specimen. × 450.

for the coiled first sets of chambers. The proloculus invariably in the material measured 12 μ inner diameter, and is provided with very fine pores. It is followed by four or five coiled chambers, and then four or three series of biserially arranged chambers are added. The chambers are low, the apertural walls slightly convex, so that the whole apertural face becomes concave at the middle. In this apertural face the large and curved aperture is seen from the two last-formed chambers, leaving an umbilical space between them. The upper border of the aperture is thickened by the attached part of the toothplate which forms a pillar by its folded part as the free part is much reduced, whereas the attached part runs along the inner wall of the chamber, forming a broad wing of clear shell-substance. This wing is attached to the axial wall of the chamber.

The sidewalls show relatively coarse pores just beneath the proximal sutures, while the distal suture is thick and hyaline, without pores. The coiled chambers show reduced toothplates at their inner corner, as is a rule in all chambers of *D. inconspicua.*

The initial end of the compressed conical test is rounded. Length of test 0,15 mm, measures of apertural face 0,25 × 0,15 mm.

The species has been described as *Textularia inconspicua* Brady by Sidebottom (Journ. Roy. Micr. Soc., 1918, p. 20) from the coast of Australia.

Discobolivina nitida nov. spec.

(Figs. 293, 294)

I found this new species in a gathering south of Sumatra, in the Mentawei-Basin, St. 2°26′ S., 99° 35′ E., depth 586 fathoms and at 2° 26′ S., 100° 0° E., depth 222 fathoms and 1° 51′ S., 99° 36′ E., depth 683 fathoms.

Several specimens were found. Most of them belonged to the megalospheric generation, one with a proloculus of 28 μ diameter, a second with 9 μ diameter. This specimen may be microspheric. It showed a tendency to be coiled in the initial part.

Test very small, typically conical with circular base, which base is slightly concave. The top of the conus is formed by the proloculus which in my specimens was megalospheric, with a diameter of about 16 μ. The conus itself is formed by 4 sets of biserial chambers. The side-walls of the conus are very hyaline and lack any trace of pores (in a figure by Moebius pores are drawn at the sidewalls, but these pores are nothing but those, found at the ventral walls of the chambers, seen through the sidewalls, as one will observe, when observing the position of those pores in the drawing of Moebius; see for literature under *D. ambulacrata.* At the ventral side two chambers are visible, the last-formed and the former chamber, and here the chamberwalls show irregularly placed comparatively coarse pores (diameter nearly 3 μ), arranged in an arched line around the apertural incurvation (very fine pores are found between the coarser ones on the ventral side, as well as on the sidewalls of the chambers). In this incurvation which is situated excentrically, the wide and yawning aperture is found, provided with a small tooth, projecting from its upper border. This tooth is the free end of a folded toothplate running from the former aperture toward the border of the next, straight through the cavity of the chamber. These folded toothplates are seen through the testwalls as thin, distinct pillars. The sidewalls of the test are slightly inflated at each chamber, the

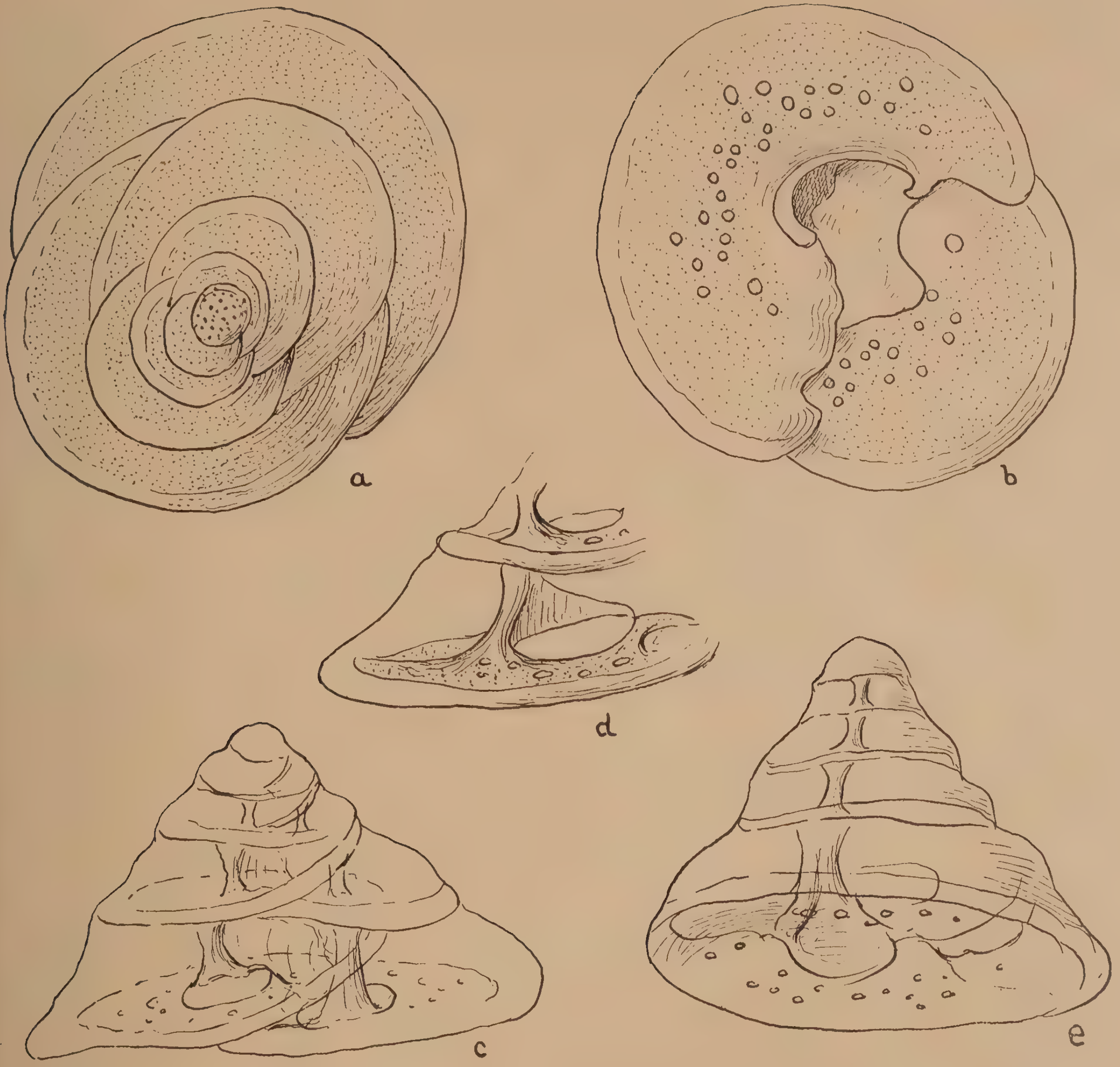


Fig. 293. *Discobolivina nitida.* a, test, seen from initial side; b, test from apertural side; c, side-view, showing position of toothplates in the hyaline test; d, end-part, enlarged, with toothplate; e, test seen from small side, with the toothplates. × 630.

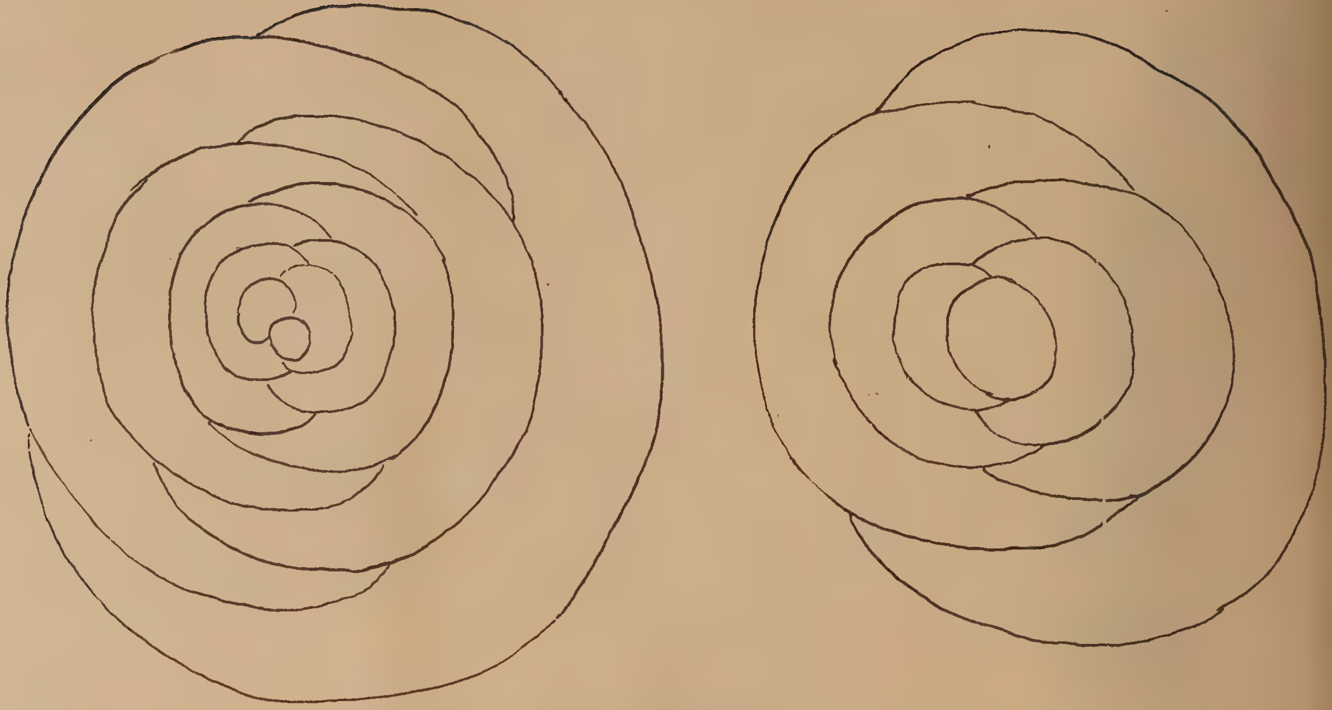


Fig. 294. *Discobolivina nitida.* a, microspheric specimen, dorsal side; b, probably A_2-individual, dorsal side; both schematic, × 630.

sutures between the chamber slightly limbate, and distinct. At the apertural face (the base of the conus) the suture between both chambers is peculiarly curved, forming a distinct sharp point at the margin.

Height of test 0,12 mm, diameter of base 0,18 mm.

Discobolivina ambulacrata (Moebius)

(Fig. 295)

This very small and beautiful species was found in St. 2° 26′ S., 99° 35′ E., depth 582 fathoms. It was found there in several specimens, all megalospheric. It occurred also at 2° 56′ S., 99° 58′ E., depth 405 fathoms, bottom temperature 8° C. It is a very small species, outgrown test measuring at its apertural face 0,13 × 0,09 mm, height of test about 0,10 mm.

Test compressed, conical, small. Chambers throughout biserially arranged, chambers somewhat inflated, with compressed sutures, distinct. Walls thin and very hyaline, with very fine pustules near the proximal sutures and a row of somewhat coarse pores along the distal suture. Very fine pores piercing the walls also. Proloculus only with fine pores. Apertural face somewhat inflated, but with a large excavation at the apertures of the last-formed chambers, forming a kind of umbilicus. Aperture at the inner side of this umbilical hollow, largely arched. No coarse pores at the apertural side. From the upper border of the aperture a toothplate emerges into the cavity of the chamber, which plate shows an attached part which narrows considerably toward the inner chamberwall, whereas the folded part is column-like. The free part is present, though reduced.

Diameter of proloculus in megalospheric specimens about 13 μ diameter.

The figures by Moebius (Mauritius, pl. 9, figs. 14, 15) of his *Bolivina ambulacrata* correspond in some respects, viz. the situation of the pores, with my specimens here; however, the other peculiarities are not clearly enough demonstrated by these figures. So there remains some doubt. He quotes about these pores: "Porenkanäle befinden sich nur in der Nähe der äussersten grössten Umfangslinie der Kammern." This agrees with our species.

As Cushman has pointed out already, my record from the Zuiderzee (1922) cannot be regarded as accurate; the Zuiderzee-specimen shows quite other characteristics.

The species has been found in the Malay-Archipelago by Millet, when he says (Journ. Roy. Micr. Soc., 1899, p. 557) from his *Textularia conspicua*: "the Malay specimens are associated with a minute hyaline *Discorbina*, to which they bear a considerable resemblance."

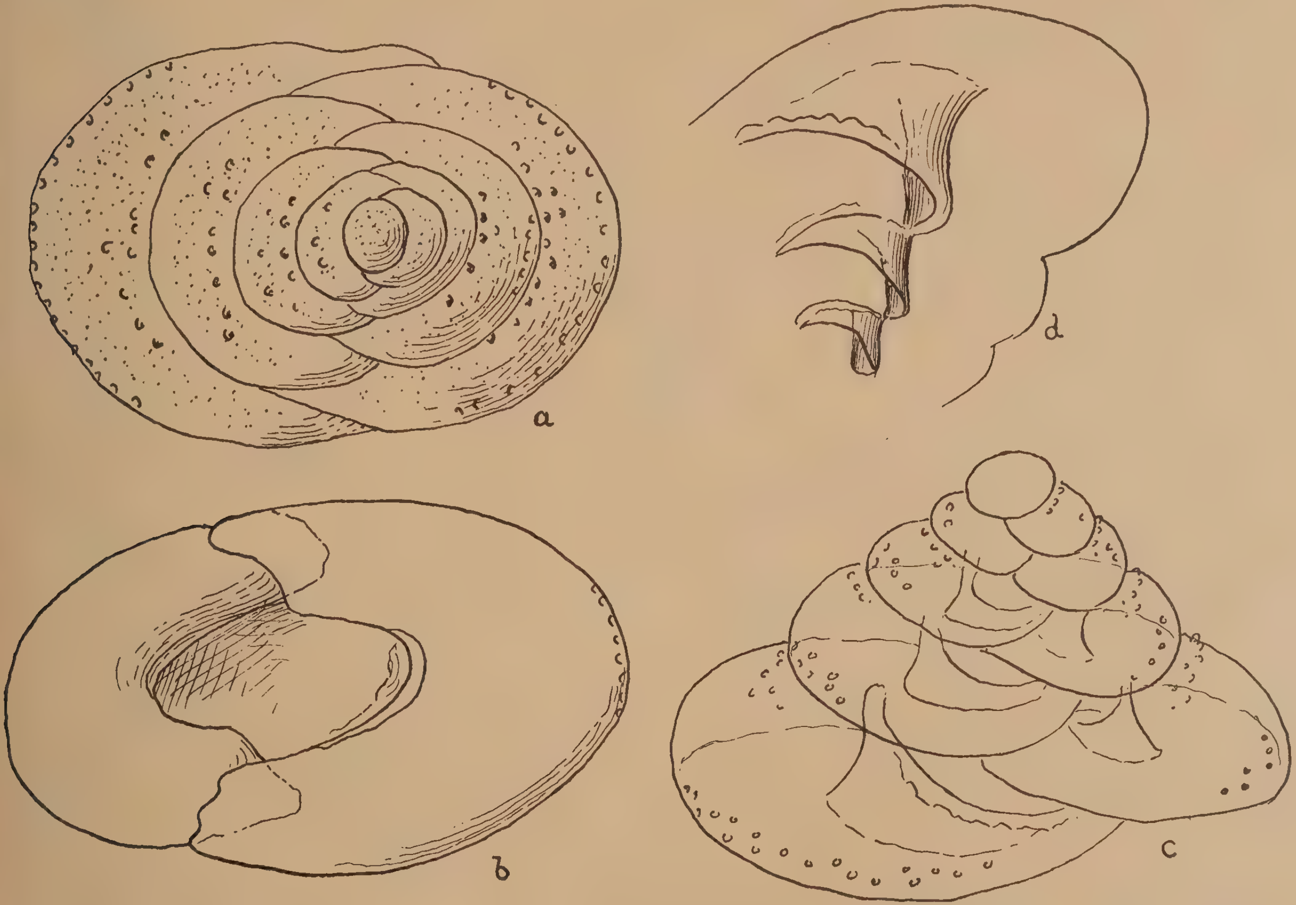


Fig. 295. *Discobolivina ambulacrata*. a. initial view; b. apertural view; c. side-view, with toothplates inside; d. toothplates within the test in optical section. × 630.

Discobolivina inconspicua (Brady)
(Fig. 296)

The species was named *Textularia inconspicua* by Brady. It was mentioned under this name by Cushman (U.S. Nat. Mus., Bull. 71, pt. 2, 1911, p. 18-19), who suggests it to be rather a *Discorbina* than a *Textularia*. In Contr. Lab. Foram. Res., vol. 4, 1928, p. 5 Cushman erected a new genus for this species, *Patellinella*, and placed it in his work "The Foraminifera" (1928, p. 270) between *Patellina* and *Discorbis*.

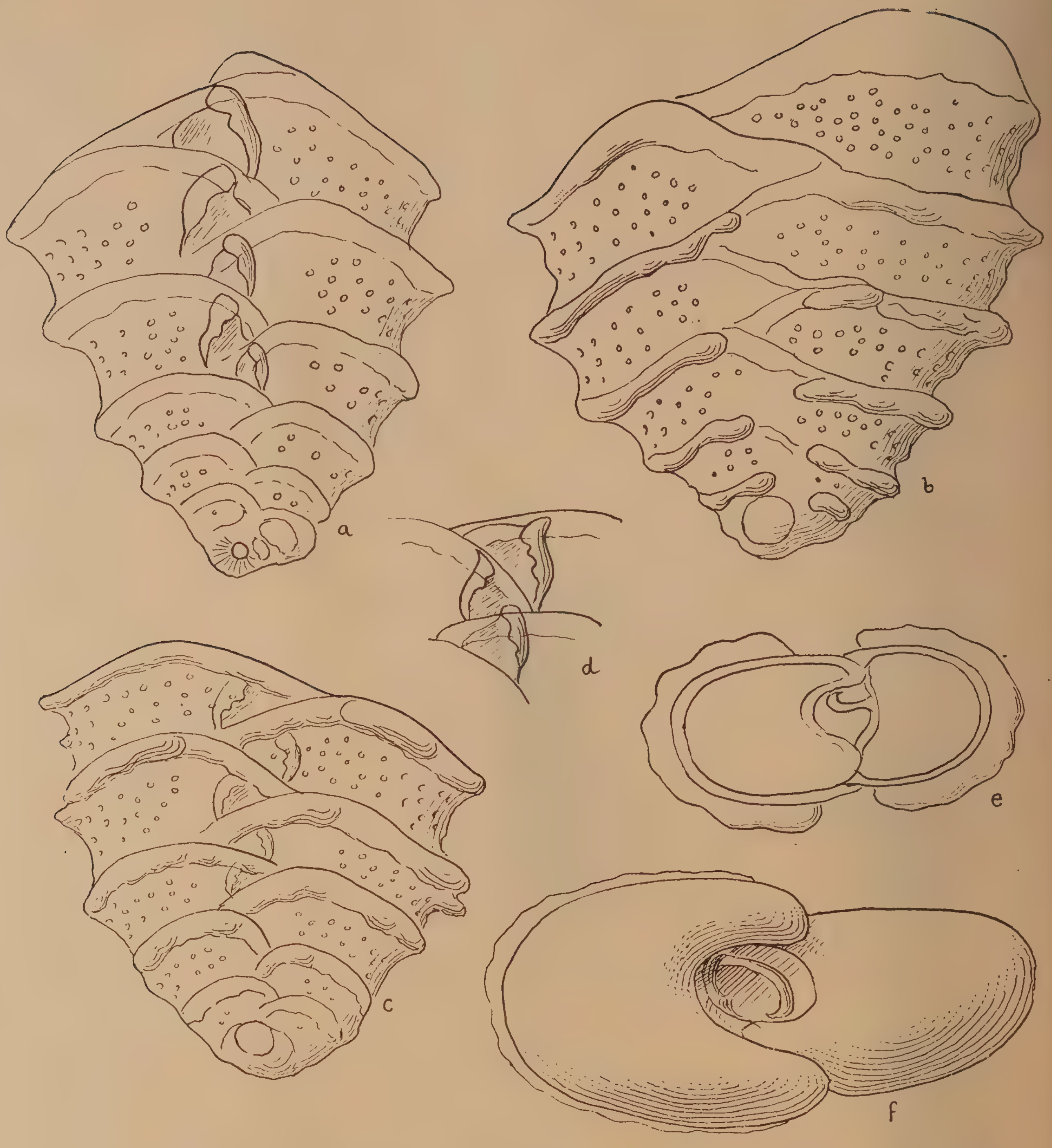


Fig. 296. *Discobolivina inconspicua* (Brady). a, microspheric individual, with the toothplates in optical section; b, A_2-form, showing position of pores; c, A_1-form, with toothplates in optical section; d, toothplates of A_2; e, transverse section, with toothplate and wing-like projections of sutures; f, apertural view. All figs. × 450.

The species has been mentioned as such by Millet (Journ. Roy. Micr. Soc., 1899, p. 557, Pl. 7, fig. 1-2) from the Malay Archipelago. But a closer examination of his figures reveals, that the pores are quite otherwise arranged than is the case in real *inconspicua.* The pores are those of *D. ambulacrata*; and, as this species also is found in several localities, it may be, that Millet had that species in mind. Real *D. inconspicua* he mentioned under the name of *Textularia inconspicua* var. *jugosa* Brady, pl. 7, fig. 2, as he mentions here "the latter, however, remarks that the rised bands of *T. jugosa* are of clear shell-substance". It reminds us of typical *Bolivina,* with its biserial arrangement of chambers, its sutural aperture with a very well developed toothplate. This plate is characterised by a curved back and a narrow and simple free plate. The pores are spread all over the walls of the chambers, except for the thickened sutures, which thickening takes often the shape of small wings, when seen in transverse section. The chambers are rounded, in section, with rounded margin, while the apertural faces are quite hyaline without pores and very much inflated. As this apertural face on the other hand is situated nearly horizontally, the apertures likewise are seen nearly in total length, in case the shell is regarded from the apertural side. Then the successive apertures are seen the one beneath the other.

Length 0,22 mm.

The species was found at the following stations:

St. 8° 15′ S., 118° 56′ E., depth 340 fathoms.
St. 10° 00′ S., 123° 19′ E., depth 453 fathoms.

In some stations south of Sumatra (2° 26′ S., 99° 35′ E., 582 fathoms and 2° 17′ S., 99° 27′ E., 377 fathoms) rare specimens were found which showed all characteristics of the species, but for the width of the test which was much smaller than in normal tests. They look like starving types, so that the typical locality is round Flores.

Yet several typical specimens were found at St. 1° 51′ S., 99° 36′ E., depth 683 fathoms, abundantly.

The species has been recorded by Millet from the Malay Archipelago.

Genus **Neoconorbina**

This genus had to be established, as its species show constantly several characteristics differing from those of *Conorbis,* with which they have been confused formerly, all members having obtained the name of *Discorbis.*

The differences with *Conorbis* are:

Toothplate reduced, but always visible as a vertical ridge close to the septal foramen; protoforamen reduced or even totally absent; only the deuteroforamen functioning as aperture, which is always found ventrally as a more or less large slit at the last-formed suture. In primitive and older species, such as *N. nitida,* the pores are protopores, mainly found at the ventral side. In more developed species the protopores are more or less absent and replaced by deuteropores, especially highly developed on the ventral side. Several distinctly separated species have hitherto been gathered under the name of *Discorbis orbicularis.*

In most species of the genus thick layers of chalk cover the dorsal side and, as those layers are rough at the surface, the test becomes more or less opaque, in transmitted light.

The type of the species is *Neoconorbina pacifica* Hofker.

Neoconorbina nitida (Williamson)
(Fig. 297)

A typically primitive species of the genus *Neoconorbina* is *N. nitida,* which I found in abundance in a sample from the drilling at America, Noord-Brabant Province, Netherlands, depth about

450 m. This is typical Eocene. It is found in similar specimens, only slightly larger in general, at the East-coast of the North Sea.

The test is more or less hyaline, dome-shaped dorsally, flattened or slightly concave ventrally. At the dorsal side the sutures are rather distinct, and oblique toward the margin. At the ventral side the sutures are somewhat curved, but they never show the typical sharply curved suture of the protoforamen, which is not present in this species. They are slightly depressed here and leave a narrow umbilicus free. This umbilicus is filled-up with chalk-material generally. There is no typical keel at the margin, though a narrow fringe is poreless here. The pores are found only ventrally, covering the whole wall, and always of the protoporous type, very fine. Sections show, that a somewhat reduced toothplate is pillar-shaped, and the septal foramina are placed dorsally and axial from the toothplate. The aperture is a narrow slit, slightly curved, with a small lip underneath.

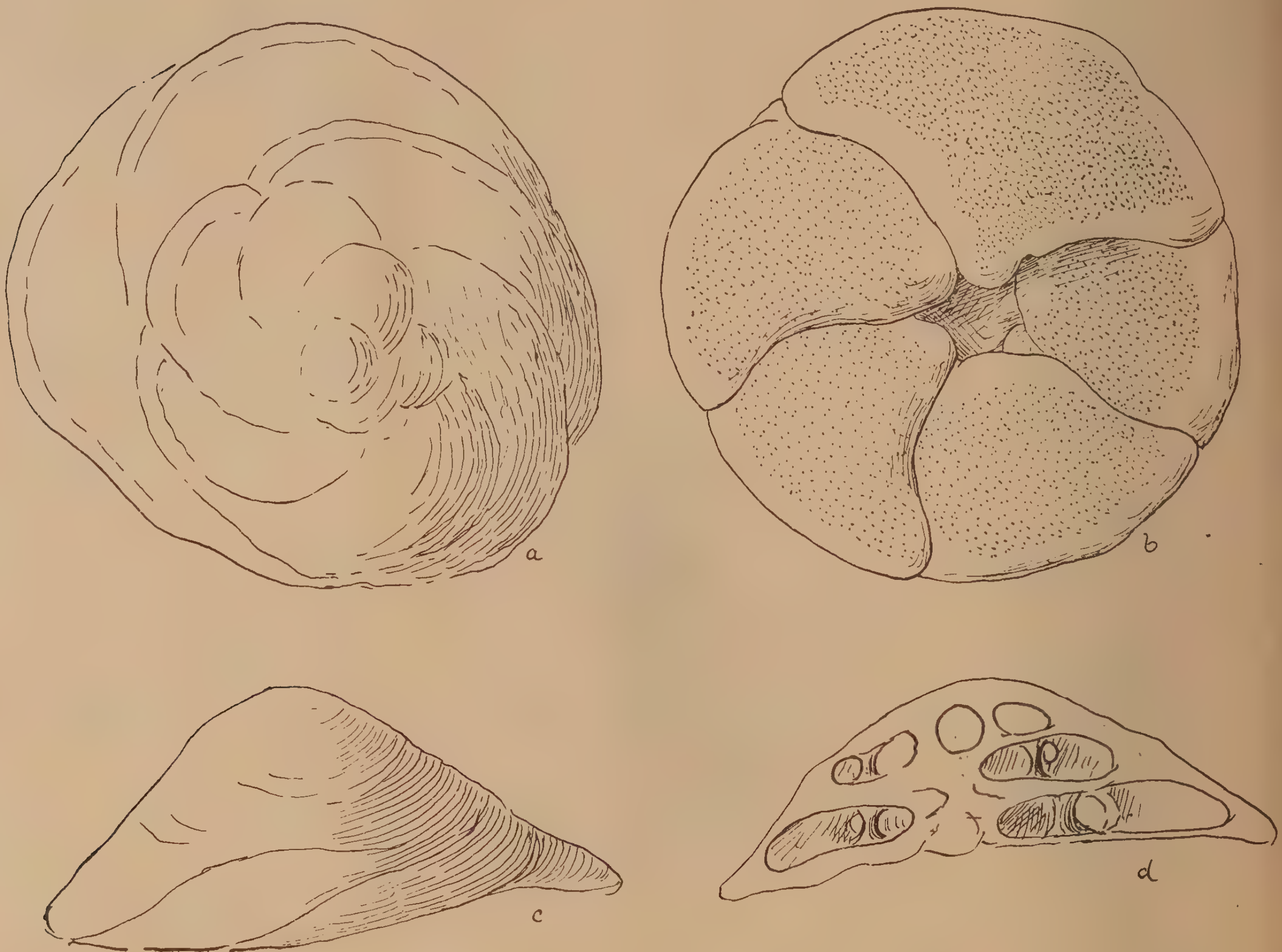


Fig. 297. *Neoconorbina nitida* from the Eocene of the Netherlands. a. dorsal; b. ventral; c. sideview; d. transverse section, showing toothplates. × 450.

Diameter up to 0,30 mm. All specimens gathered were megalospheric, with a proloculus of about 25 μ diameter.

Neoconorbina marginata nov. spec.
(Figs. 298, 299)

The species was not uncommon at St. 1° 51′ S., 99° 36′ E., depth 683 fathoms. It occurred also at St. 8° 15′ S., 118° 56′ E., depth 340 fathoms, 2° 34′ S., 99° 44′ E., depth 777 fathoms, and 2° 26′ S., 99° 35′ E., depth 582 fathoms. In all specimens observed the proloculi were small, with a diameter of about 12 μ.

Description. Test rounded, dorsal side convex, with a pointed top, covered with irregular chalk material, so that the first chambers are not clearly visible. The chambers on the dorsal side are slightly inflated, and the sutures slightly depressed. At the dorsal side pores are few and scattered over the surface.

The ventral side is hollow, with a deep and relatively wide umbilicus. Only three or four chambers visible at the ventral side. Each chamberwall here is folded smoothly toward the umbilicus with a somewhat irregular toothlike projection. At the ventral side numerous coarse pores are found; they have a diameter of about 4 μ. The irregular bordered umbilicus is deep, so that one can see the first coils of chambers through it. A poreless and more hyaline carina borders the whole shell; this carina shows fine radiate ornamentations. It is slightly folded upward, when seen from aside.

Total diameter of test up to 0,30 mm, height up to 0,13 mm. The spirally arranged chambers open only into the umbilicus with a wide foramen which ventrally is covered by the ventral shellwall folded toward the inner side of the umbilicus and upward.

Often tests show no pores at all on the dorsal side.

There are at least three different species hitherto described as "*Discorbis orbicularis*" Terquem. Those from the English coast are poreless at the dorsal side, and show distinct protopores at the ventral; this seems to be the species, described from Dunkerque by Terquem; it should be called *Neoconorbina orbicularis* (Terquem).

A second species occurs in the Mediterranean (Golf of Naples), and is characterised by rows of pores along the sutures at the dorsal side (deuteropores) and scattered deuteropores at the ventral side, whereas the aperture, situated near the umbilicus, is very wide and often shows a rounded toothlike lip. The sutures are distinct at the dorsal side, and the margin is not keeled; protopores are reduced or even absent.

A third species is found in the West-Indian region. Here too protopores are seemingly absent, but the deuteropores are much smaller than those of the Mediterranean species. Both dorsal and ventral walls are covered with those deuteropores; the sutures at the dorsal side are distinct, and the aperture near the umbilicus shows always a very distinct lip or tooth, obviously connected with the toothplate, which in this species is much more distinct in sections than in any of the other ones.

The specimens of the Pacific region differ from those of the Mediterranean in several constant characteristics. The margin here shows always a hyaline massive keel which at its ventral side shows typical radial ornamentations which, however, do not extend at the ventral wall itself, so that they cannot be confused with *D. selseyensis* Heron-Allen et Earland. At the ventral side the deuteropores are much more numerous than in the Mediterranean species, and the dorsal side shows only scattered deuteropores which are very large. The sutures at the dorsal side are indistinct, and the wide aperture near the umbilicus shows in most cases observed no toothlike lip. I have called this distinct species *Neoconorbina marginata* nov. spec.

I give here too some figures of the Mediterranean species, to show the differences.

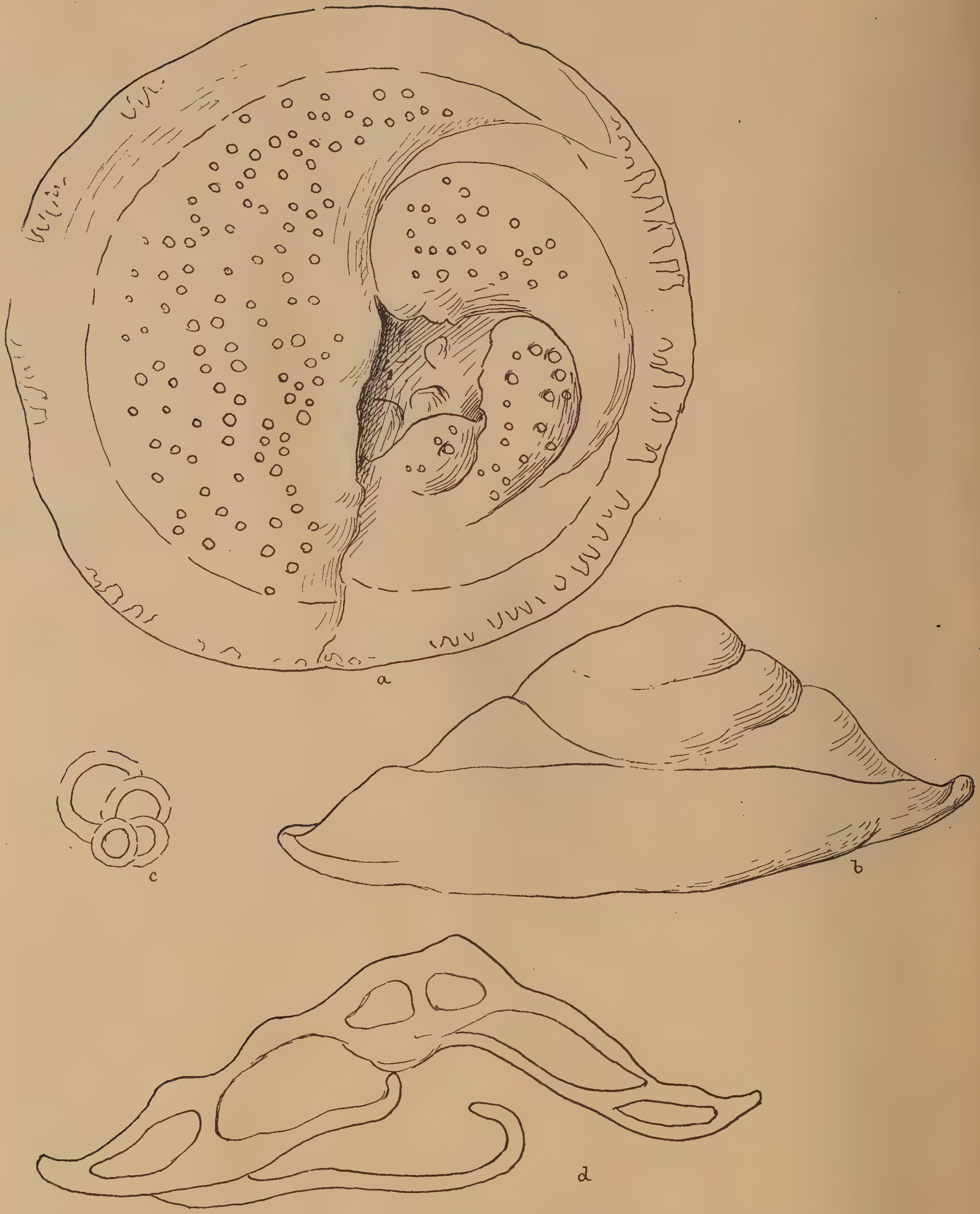


Fig. 298. *Neoconorbina marginata.* a, ventral side, showing umbilical aperture; b, sideview; c, section through initial part; d. transverse section, showing aperture toward umbilicus. × 450.

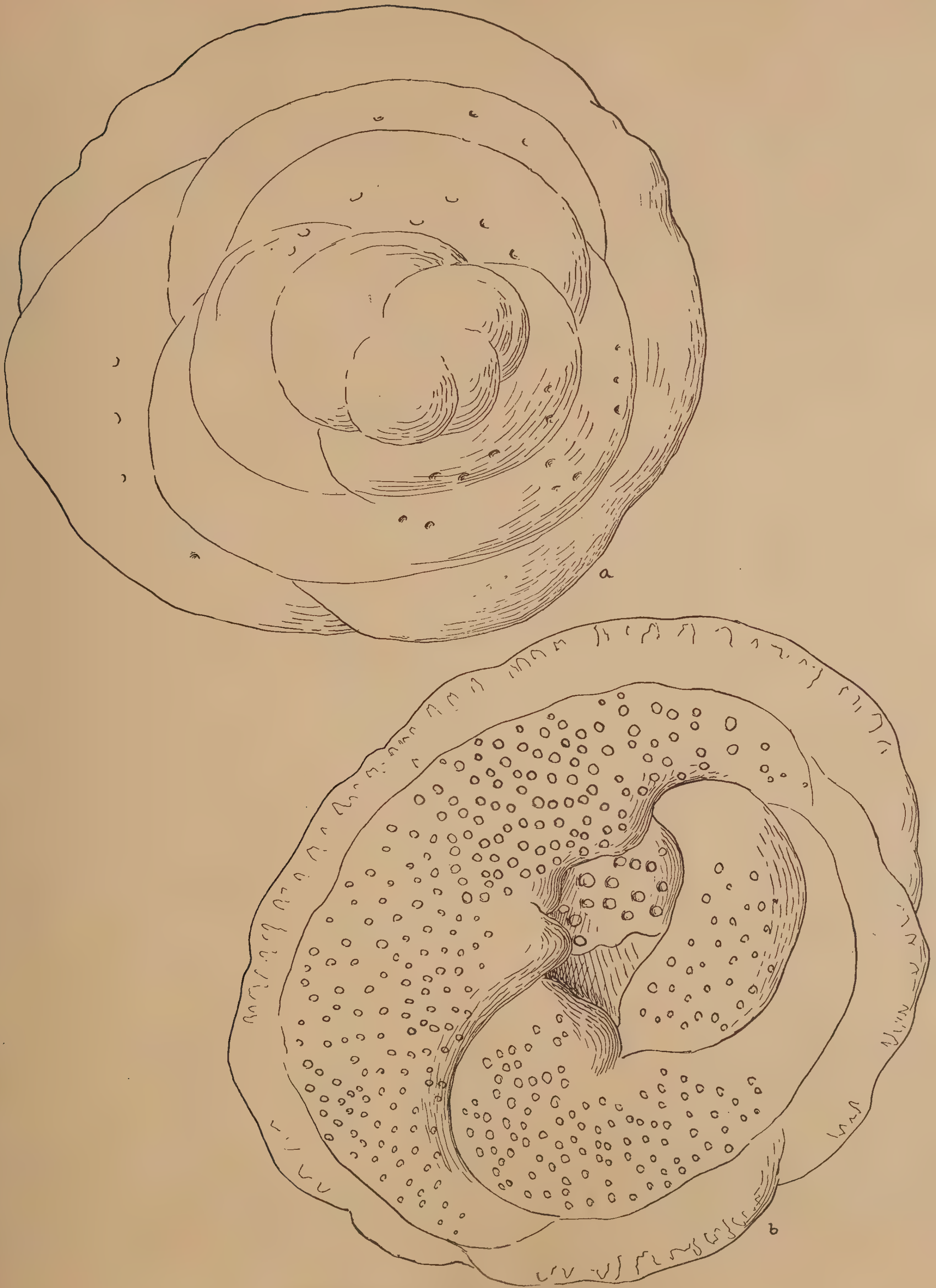


Fig. 299. *Neoconorbina marginata.* a. dorsal; b. ventral side; × 450.

Neoconorbina neapolitana nov. spec.
(Figs. 300, 301)

In the Bay of Naples many specimens occur of a species belonging to the *orbicularis*-group, but differing from those, found around England, as well as from the species, hitherto also called *Discorbis orbicularis,* occurring in the Pacific and possibly in the West-Indian area. At the dorsal side of the conical test deuteropores are found along the sutures which at the older chambers are scarcely visible; the margin does not show a typical keel as in the Pacific species, while ventrally the large deuteropores are only scattered on the walls. The protoforamen is very much reduced, whereas the aperture is very wide and provided with a distinct and broad lip, extending over the umbilical hollow. The ventral side is concave and the umbilicus open up to the first-formed chambers.

I give this species here to show, that quite different species have hitherto been mentioned as "*Discorbis orbicularis*" Terquem.

Neoconorbina pacifica nov. spec.
(Figs. 302, 303)

A species, occurring at anchorage off Merak, Strait Sunda, in its outer characters resembles somewhat *Asterigerinata mamella*: very thick but hyaline walls, conical shape, deuteropores at dorsal side, ventral side without pores, thickened rounded plate-like protuberances over the protoforamina at ventral side. It seems closely allied to *Discopalvinulina turbo,* but the ventral side is different.

But a closer examination shows, that this species cannot belong to the genus *Asterigerinata,* as the toothplates are very much reduced, and only present at the border of the protoforamina; from these foramina only that of the last-formed chamber is clearly visible; the older ones are more or less closed by the chalk-masses developed on the ventral side which are quite hyaline, but lack any traces of pores. They show to be nothing but thickenings of the ventral walls and have nothing to do with the protoforamina itself or the toothplates. The septal foramina are rounded and small, as in the genus *Conorbella,* and are situated in the ventral part of the chambers. Thus this species shows all characteristics of the genus *Neoconorbina* and some features of *Conorbella,* but none of *Asterigerinata.* I believe it to belong to the genus *Neoconorbina,* with some very striking characters pointing to *Discopulvinulina* also. It may be, that from species like this one the genus *Discopulvinulina* developed. In that genus too the ventral side is thickened, whereas the dorsal side shows only deuteropores with traces of protopores between.

The description of the species runs as follows:

Test small, dorsal side a cone rounded at its top, ventral side flat or slightly concave. At dorsal side sutures distinct and thickened, very much oblique and chambers narrow but long, in the end rapidly increasing in length, up to more than half the circumference. At the ventral side walls thickened and smooth, only sutures of last-formed chamber distinct with distinct protoforamen, near to the centre, and more distally with a wide rounded aperture, covered by a distinct lip with smooth border. The older chambers only partly visible with irregular sutures and surface smooth and thickened, leaving free a distinct but narrow umbilicus. Walls at dorsal side with rather coarse deuteropores, especially along the sutures, scattered over the whole surface, ventral side without

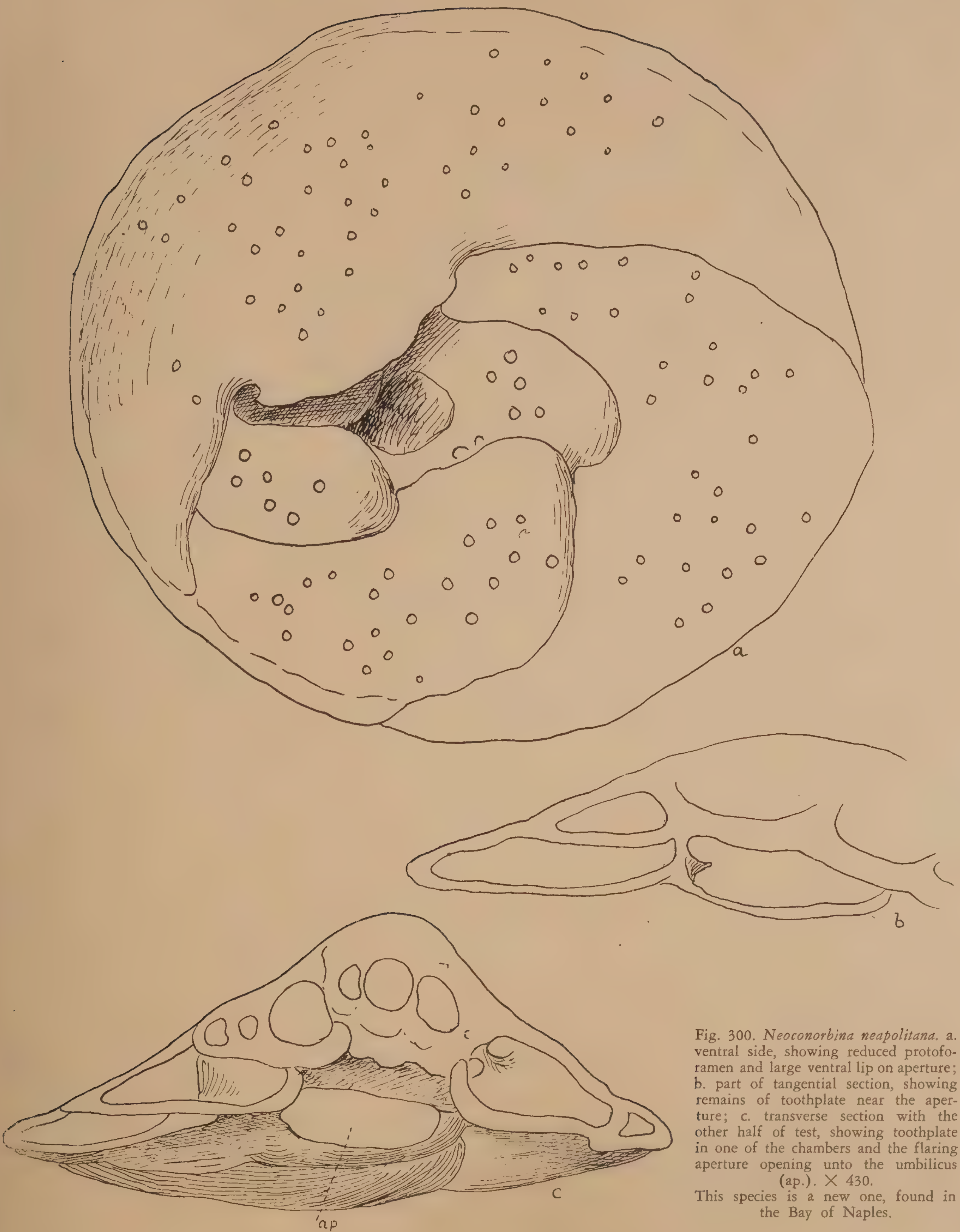


Fig. 300. *Neoconorbina neapolitana.* a. ventral side, showing reduced protoforamen and large ventral lip on aperture; b. part of tangential section, showing remains of toothplate near the aperture; c. transverse section with the other half of test, showing toothplate in one of the chambers and the flaring aperture opening unto the umbilicus (ap.). × 430.

This species is a new one, found in the Bay of Naples.

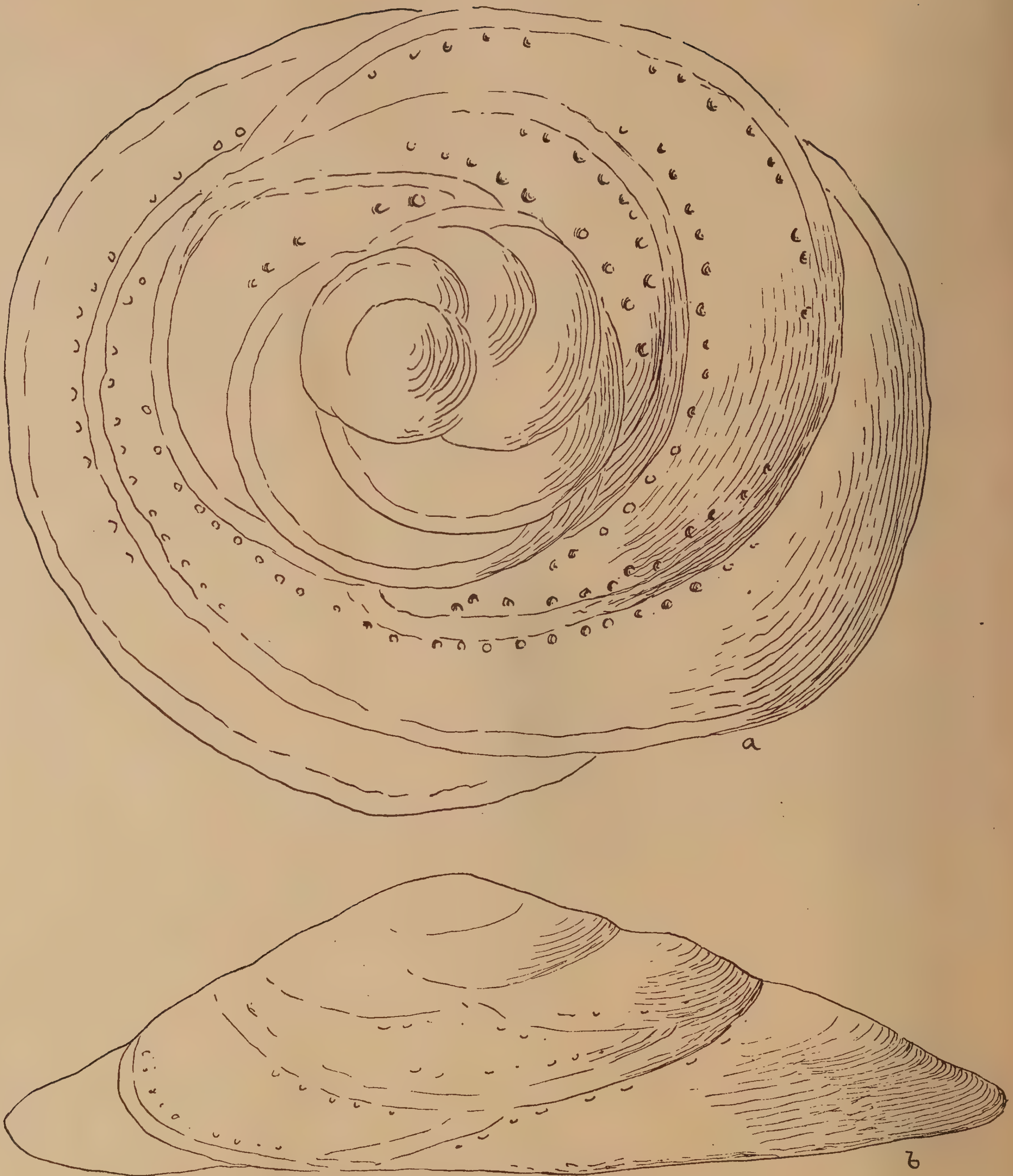


Fig. 301. *Neoconorbina neapolitana.* a. dorsal side; b. sideview. × 480.

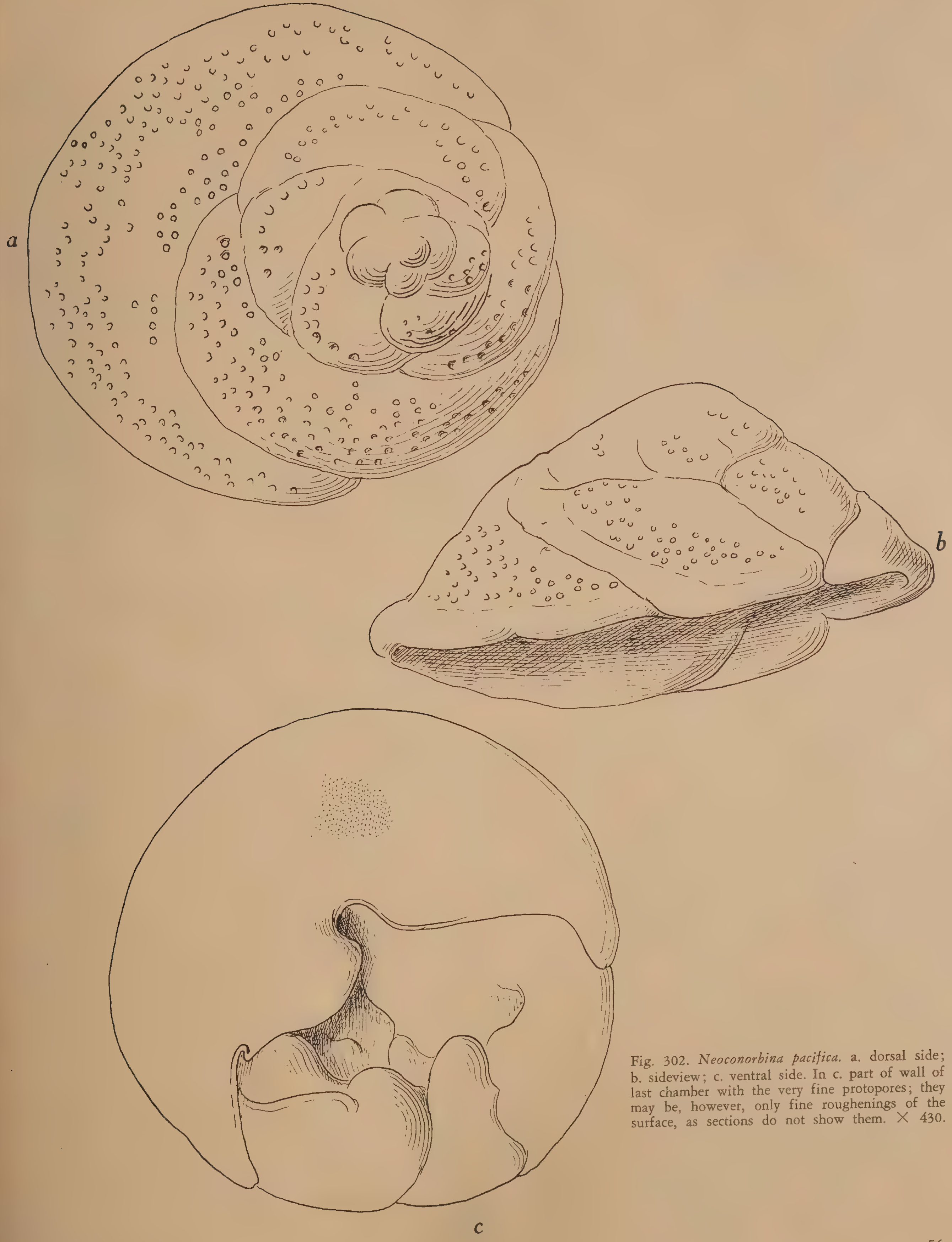


Fig. 302. *Neoconorbina pacifica.* a. dorsal side; b. sideview; c. ventral side. In c. part of wall of last chamber with the very fine protopores; they may be, however, only fine roughenings of the surface, as sections do not show them. × 430.

pores or with traces of very fine protopores, rapidly vanishing under the thick layers of secondary chalk.

Megalospheric specimens with relatively large proloculus, followed by at least three whorls of chambers, in the first coils 6 in a coil, later three or even two.

Diameter of test up to 0,35 mm, height 0,10 mm. Not uncommon at Merak, depth about 10 fathoms.

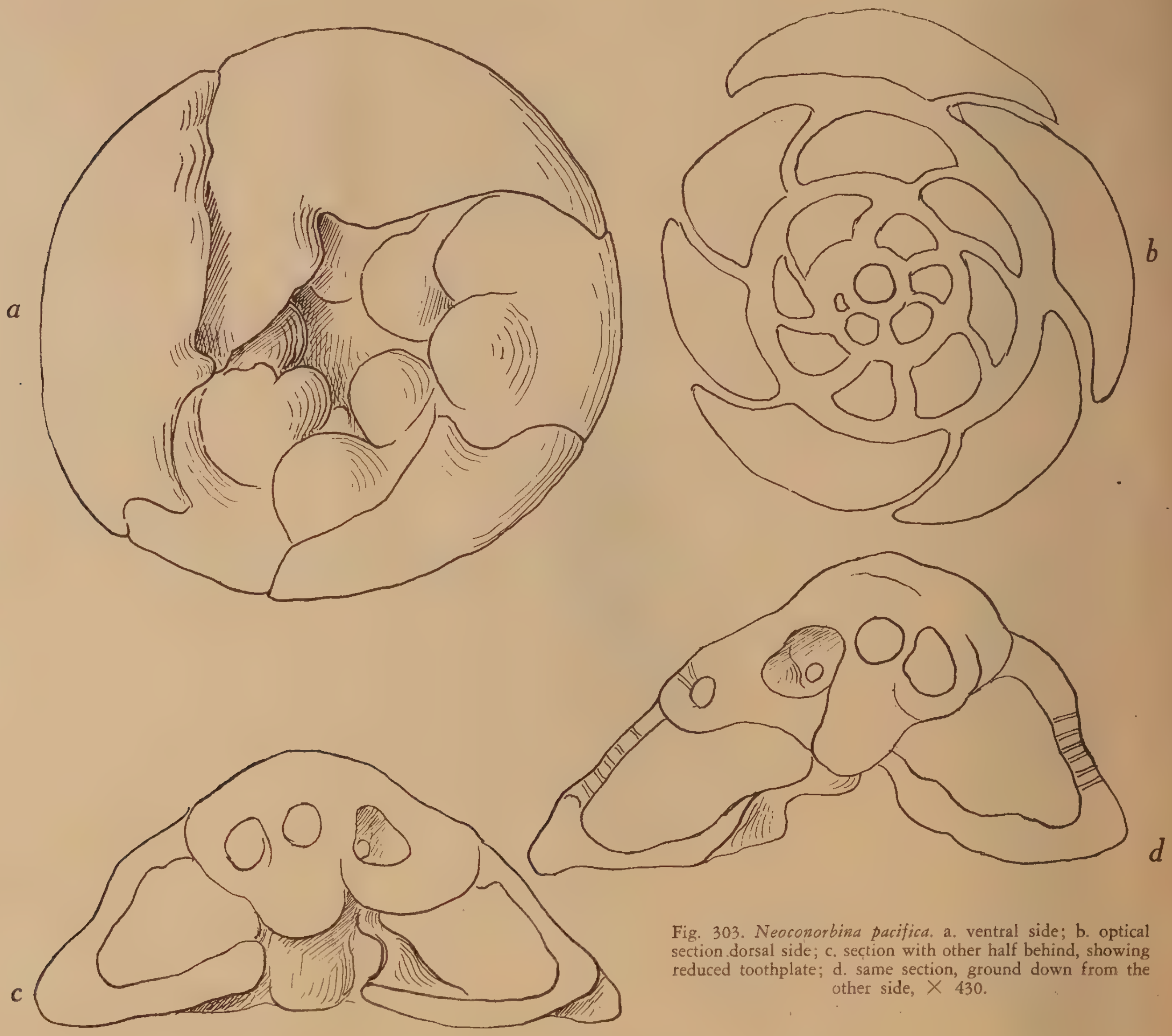


Fig. 303. *Neoconorbina pacifica.* a. ventral side; b. optical section dorsal side; c. section with other half behind, showing reduced toothplate; d. same section, ground down from the other side, × 430.

Genus **Amphistegina**

Cushman, Galloway and Glaessner in their works on general Foraminiferology have pointed out, that the genera *Asterigerina* and *Amphistegina* are closely allied and form a homogenous group which they call the Family of the *Amphisteginidae*.

In my Siboga-Monograph, Part I, 1927, p. 75, I suggested, that this Family has nothing whatever to do with the *Nummulitidae.* In that work I could deal only with adult specimens of *Amphistegina radiata* Fichtel et Moll, and I found, that *Amphistegina lessonii* and *A. Madagascariensis* both by d'Orbigny, are only generations of *A. radiata.*

I was now able to study many young specimens of this species, and now I can add many new data to my views from 1927.

In a recent work of mine on *Asterigerina gurichi* from the Tertiary of the Netherlands, I gave a study of the inner structure of the test of *Asterigerina.* I showed here, that the genus *Asterigerina* must be closely allied to the *Ceratobuliminidae,* as it shows a real toothplate, and as the so-called supplementary chambers are nothing but the ventral parts of the chambers, situated ventrally to the toothplate. This view was underlined by a new study of *Asterigerina carinata* from the West-Indian region, in which study several other fossil species of *Asterigerina* were mentioned too. The knowledge which I got from the Jurassic species *Reinholdella dreheri* gave me a good insight in the real descent of *Asterigerina,* and I could prove, that this genus must have derived from ancient *Conorbis*-species which, in there turn, are very closely allied to *Epistomina,* belonging to the *Ceratobuliminidae.*

In my paper on *Asterigerina gurichi* I came to the suggestion, that the genera *Asterigerina* and *Amphistegina* are not at all allied to one another, as I believed from my former investigations, that the genus *Amphistegina* is planospiral throughout. My new investigations on young *Amphistegina radiata* have proved this thought to be an erroneous one (See Journ. of Paleont., Vol. 22, 1948, p. 511).

Brotzen (Sver. Geol. Unders., Ser. C., No. 493, 1948) when dealing with *Asterigerina* (p. 125-126) has come to the conclusion, that both genera *Asterigerina* and *Amphistegina* are not related, when he states: "The common character of these two genera is the occurrence of so-called supplementary chambers; all other characters, the shape of the chambers, the position of the aperture, and the structure of the wall, are so different that there cannot exist any relationship between these genera."

The study of young specimens of *Amphistegina radiata* showed me, that *Amphistegina* has a real toothplate which develops at the same time, as a new chamber is formed, and then a supplementary chamber at the ventral side is added too. This phenomenon is also found in true *Asterigerina.* The shape of the pores, the typical chalk-knobs around the aperture, they are found also in *Asterigerina.* The only typical differences between *Asterigerina* (which in itself is a rather variable genus) and young *Amphistegina* are the shape of the aperture and the thickness of the walls, together with the most typical fact, that in *Amphistegina* the normal chamber-parts are overlapping at the dorsal side, which in *Asterigerina* never is the case. The overlapping at the dorsal side gives rise to the planispiral type of many outgrown specimens of *Amphistegina.*

Description of the genus *Amphistegina:*

Primitive and young species with typical trochoid test, in all features resembling *Asterigerina.* Chambers of later whorls overlapping those of former ones at dorsal side with often very irregularly shaped prolongations. Aperture a small but arched opening at ventral suture, covered by a narrow lip underneath. Apertural face without pores and covered by many small chalk-knobs. When a new chamber is added, a toothplate is formed first which, contrary to *Asterigerina,* is not running horizontally, but more or less vertically. Underneath this toothplate, closing the reduced protoforamen, and thus situated intersutural, is formed a porous wallet, closing in a narrow supplementary chamber, in young specimens formed as in *Asterigerina.* These supplementary chambers at the ventral side show in transverse section to be nothing but the ventral parts of the chambers. In highly-developed species, as in *A. radiata,* these supplementary chamberlets become confused and irregularly shaped and are often overgrown by ventral alar prolongations of the chambers themselves. Walls always thick and the lumen of the chambers narrow; pores always protopores as in *Asterigerina.*

As my *Amphistegina fleuriausi* from the chalk of Maestricht does not show any traces of a toothplate, and as this species shows nothing of supplementary chambers, it cannot belong to the genus *Amphistegina,* but seems to belong to the *Camerinidae.* I am only very certain, that it does not belong to the genus *Operculina,* to which it has been thought to be related by many authors. Thus *Amphistegina* is known from the Tertiary to recent times only.

Amphistegina radiata Fichtel et Moll
(Figs. 304-304b)

I have already given a full description of the adult forms of this species in my Siboga-Report, pt. I, p. 76-78; I can fully underline now my statements mentioned there.

I found many specimens of this species in the gatherings I studied now from the Malay Archipelago. At St. 1° 51′ S., 99° 36′ E., depth 683 fathoms I met with many youngsters of this species which I could study statistically as well as structurally.

Statistic study of the size of the proloculus showed four specimens with a proloculus of about 6-10 μ diameter. These specimens showed a total different test structure with regard to the two other forms. The chambers are low and very long consequently, at the ventral side the supplementary chambers are irregularly shaped, and no central clear chalk-knob is visible, whereas the apertural face is very small, with only few chalk-knobs surrounding the aperture, which is very narrow and hardly visible.

A second group of individuals shows a diameter of proloculus from 15-30 μ, whereas the shape of the chambers is much higher, the apertural face larger, and protuberances and chalk-knobs scattered over this face. The aperture in many cases is clearly shown and always covered by a typical lip. From this generation, the A_1, 25 specimens were found.

The third group shows a relatively large proloculus, measuring from 40-90 μ, a large clear knob of chalk is found in the centre of the test, the chambers are very regularly shaped and the sutures much clearer than those of the foregoing generations, whereas the number of chambers is relatively few. The apertural face is very large, the aperture always well visible.

The number of chambers in the last formed whorl increases with the age of the test, and thus cannot be regarded as a typical specific character. Specimens with a total diameter of 0,10-0,2 mm show 4-5 chambers in the last-formed whorl, those of 0,20-0,30 mm 6-8 of them.

The structure of the test in these young specimens proved, that it can be considered to be nearly identical with that of *Asterigerina,* thus confirming the view of Glaessner and Cushman, that the genera *Asterigerina* and *Amphistegina* are closely related. Each chamber, following the proloculus (except for the second one which forms with the proloculus a not so well-defined two-chambered embryo as in *Asterigerina*) in transverse section is divided into two parts, a dorsal one and a ventral one, by means of a distinct toothplate, not, as in *Asterigerina,* running horizontally, but obliquely. The smaller part is the ventral one, forming the socalled supplementary chamber, running underneath the proloculus toward the clear umbilical chalkmass, whereas the dorsal part overlaps

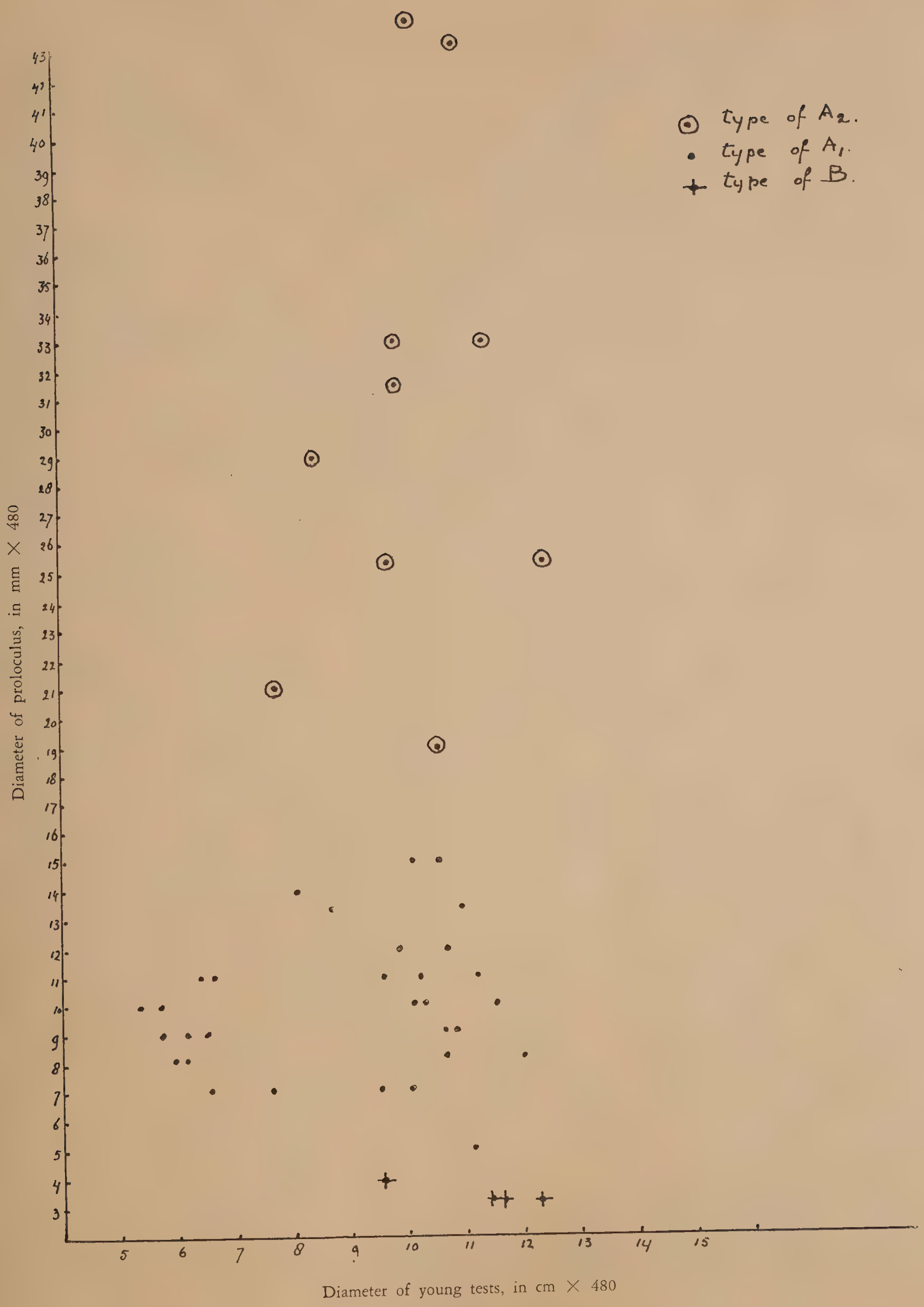


Fig. 304. Diagram, showing relation between diameter of test and diameter of proloculus in young specimens of *Amphistegina radiata,* all deriving from a single locality. The species thus shows to be certainly trimorphic, as in all samples, as well from the Pacific as from the West-Indies these three forms are found together and no other forms.

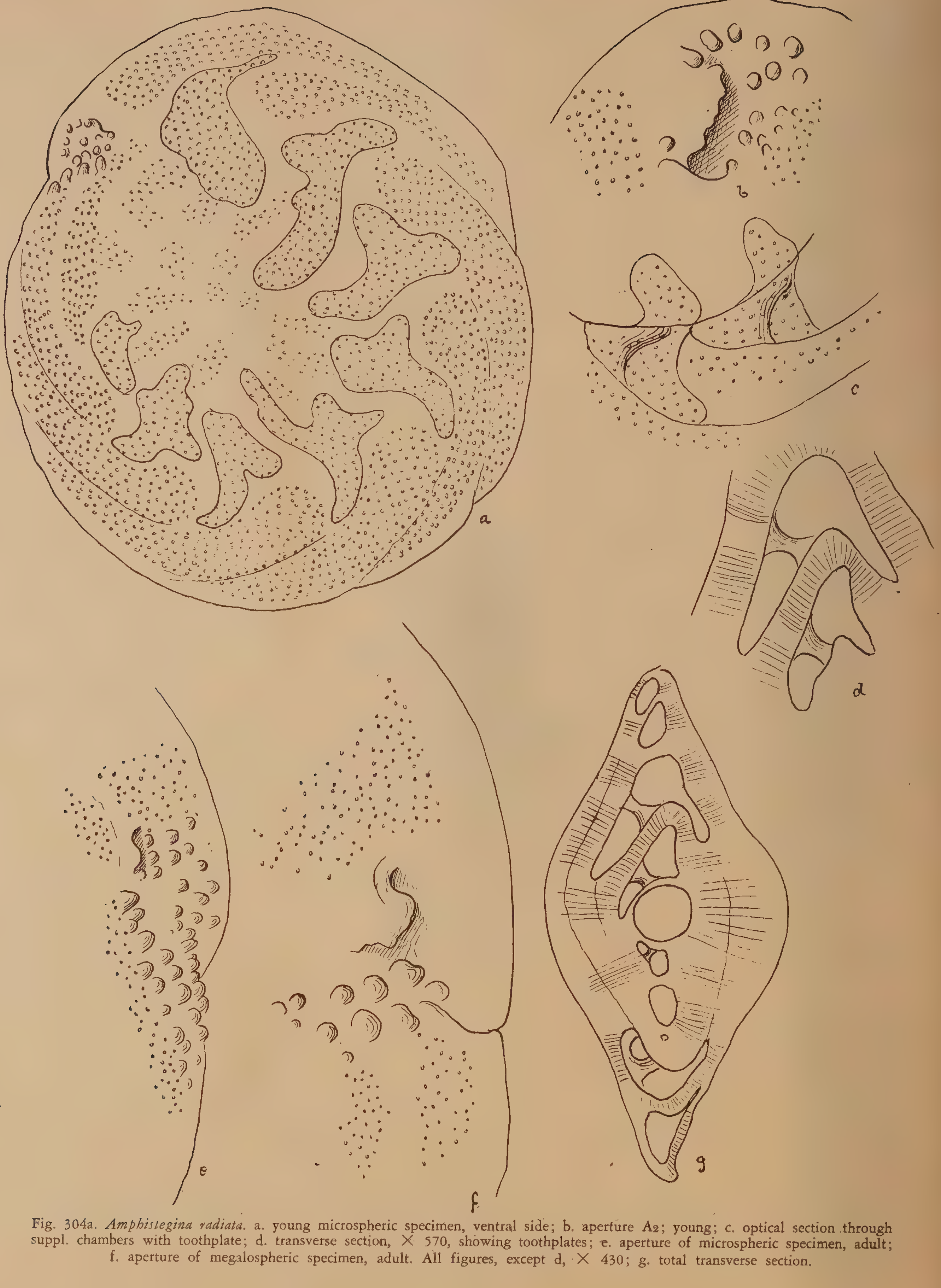


Fig. 304a. *Amphistegina radiata.* a. young microspheric specimen, ventral side; b. aperture A_2; young; c. optical section through suppl. chambers with toothplate; d. transverse section, × 570, showing toothplates; e. aperture of microspheric specimen, adult; f. aperture of megalospheric specimen, adult. All figures, except d, × 430; g. total transverse section.

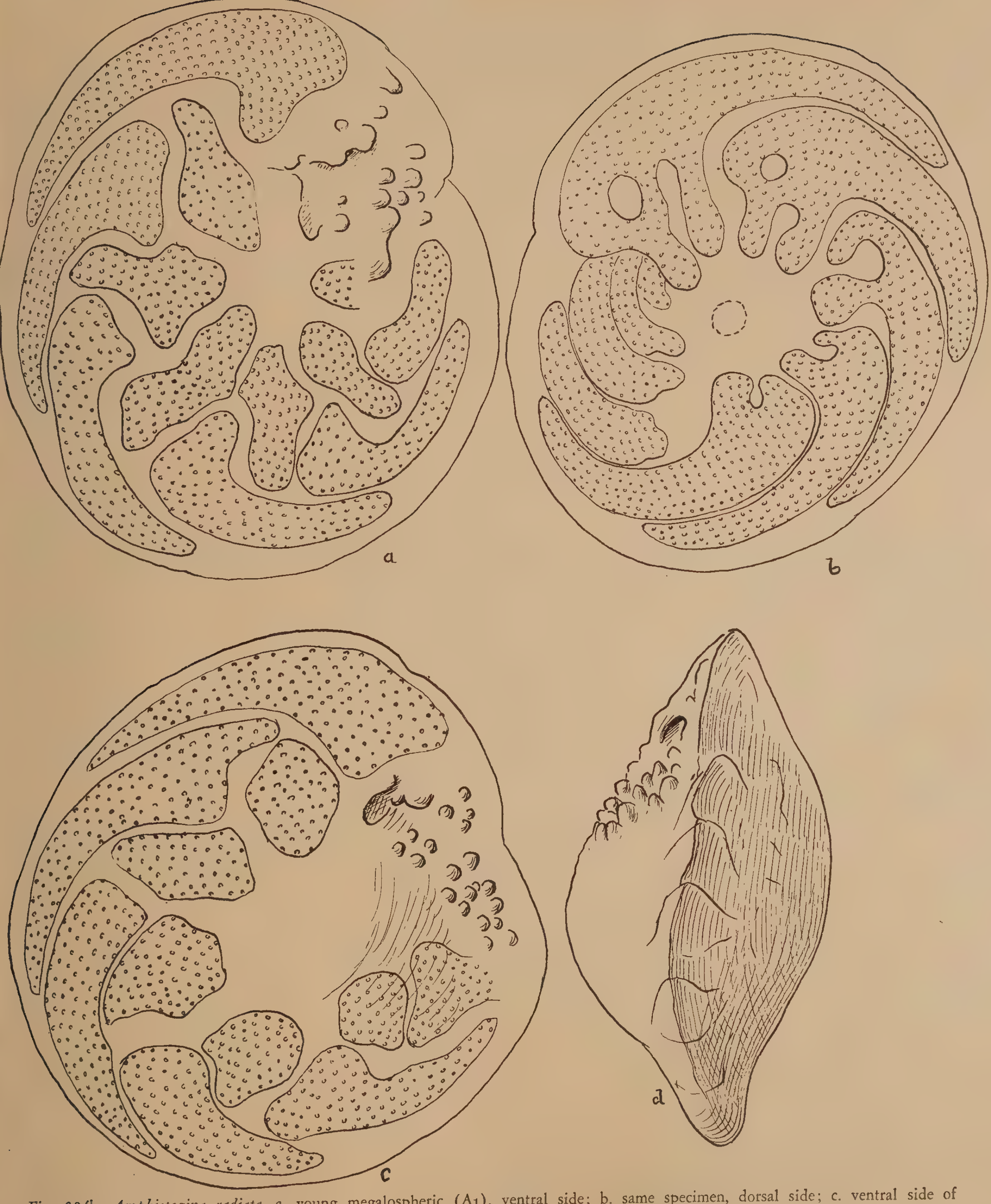


Fig. 304b. *Amphistegina radiata.* a. young megalospheric (A_1), ventral side; b. same specimen, dorsal side; c. ventral side of A_2-specimen; d. sideview of megalosperic individual. × 450.

the dorsal side of the test with a very low alar prolongation for a shorter or longer part. These overlapping dorsal alar prolongations distinguish mainly the genus *Amphistegina* from *Asterigerina.* The walls are always very thick and pierced by distinct protopores. Dorsally and ventrally the sutures between the chambers are smooth and only distinguishable by the lack of pores. The dorsal alar prolongations in later chambers become forked and irregular, often with anastomosing parts. At the ventral side the supplementary chambers often grow irregularly in more adult specimens.

This investigation clearly shows us, that the genus *Amphistegina* is very closely allied to *Asterigerina.* It is *Asterigerina* with dorsal alar prolongations.

This view makes it possible, to distinguish between *Asterigerina* and *Amphistegina.* It seems, that *Amphistegina gibba* d'Orbigny from the West Indian region is more primitive than *A. radiata* from the Pacific, as in the adult form it shows clearly the difference between dorsal and ventral side. *Asterigerina subacuta* Cushman, *Asterigerina choctawensis* Cushman and McGlamery, *Asterigerina bracteata* Cushman from the Oligocene of America are true, though primitive *Amphistegina* and no *Asterigerina,* as they clearly show their chambers overlapping dorsally. But only transverse sections may reveal this without doubt.

Family *Pulvinulinidae*

This family includes the genera *Discopulvinulina* and *Conorbella.* In its more primitive forms it shows two open foramina at the end-chamber, the protoforamen and the deuteroforamen, which always are separated by a more or less protruding lip. In *Discopulvinulina* one distinguishes at the ventral suture the deuteroforamen, found near the margin, the large lip, covering part of the umbilical cavity and forming an opening towards that cavity, and the narrow protoforamen. This protoforamen in higher forms is reduced or even absent. The toothplate is more or less reduced. The lip always is poreless, and often the whole ventral side also. In geologically older forms and in primitive recent ones protopores are found, but in more highly developed forms deuteropores are developed. In many species there exist a clear poreless margin between ventral and dorsal side, thus pointing to the *Marginolamellidae.*

In the genus *Conorbella* the protoforamen is lost, whereas the deuteroforamen is very narrow. Here protopores are found, and at the ventral side always fine radiating ornamentation is seen. Many species of this genus show a typical conical form, whereas in *Discopulvinulina* the form often is a flattened one.

Asterigerinata shows primitive and more developed characters together. Protopores and deuteropores are found, the deuteropores always placed near the sutures. The protoforamen is very well developed, and the lip more or less reduced. But the toothplate itself forms a plate, closing in older chambers the protoforamen, as in *Reinholdella,* but in the latter genus this plate is not formed by the toothplate. The genus may be related to the *Amphisteginidae* or may even belong to that family.

Many species of this family have been described formerly as *Discorbis.* The family is traced down to the Upper-Cretaceous.

Genus **Discopulvinulina,** nov. gen.

Species, in which in primitive forms the pores are very fine (*"Discorbis" binkhorsti*); later species show coarse "pores" which, however, are nothing but groups of very fine pores, surrounded by a thickened wall which is thickened by clear secondary chalk-material.

The chambers are constantly arranged in a flat conical spire, always beginning with a single proloculus (not a bilocular embryo). The ventral side is flattened, the dorsal one often convex, but not heavily. The aperture (deuteroforamen) is a more or less arched slit, beginning ventrally from the margin, and running down toward the umbilical region. It shows at the margin a more or less reduced toothplate and is ventrally covered by a more or less irregular lip which first runs toward the umbilical region, and then runs back often with a sharp angle toward a fissure, at the middle of the ventral chamber suture, which fissure (protoforamen) always stands in connection with the toothplate of the former chamber and is situated just underneath the septal foramen. Here the lip ends underneath the aperture, and also the aperture itself. At the ventral side often the chamberwall is quite poreless and hyaline, and never pores are found at the margin, thus indicating, that this margin is formed by the toothplate which is also found, as has been said already, at the margin where the aperture begins. The septal foramen is found in older chambers in the middle or ventrally from the middle of the chamber suture. This septal foramen is the remaining part of the long ventral aperture of the last formed chamber. In the last formed chambers the ventral aperture may remain open at the umbilicus, in older chambers it is always reduced up to the septal foramen. The ventral hyaline poreless wall may be partly formed by the toothplate itself, as is perhaps the ventral apertural irregular lip. The aperture is always found near to the margin, the apertural lip always axially from it.

This genus includes some forms, in which the overlapping by the chambers on the dorsal side has become total, together with other forms, in which there is no overlapping at all. Intermediate forms occur also. Those with totally overlapping chambers have been gathered by Brotzen in 1936 into the genus *Cibicidoides*. But, since other species, obviously belonging also to the genus *Discopulvinulina,* do not show any tendency to overlap at the dorsal side, and since some other forms, occurring especially in the West-Indian region, show only partial overlapping, this feature cannot be a generic one, and consequently the genus *Cibicidoides* had to be dropped. This was the more advisable, as the name *Cibicidoides* points to a relationship with the genus *Cibicides* and, as I show here in my exposure of the *Cibicidae,* that there is no relation between *Discopulvinulina* and *Cibicides,* this name would easily lead to errors. So it has to be dropped, and I gathered the total number of species into a single genus, *Discopulvinulina.*

The type of the genus is *Discopulvinulina bertheloti* (d'Orbigny).

Discopulvinulina turbo (d'Orbigny)

(Figs. 305, 306)

This species occurred in some abundance in the anchorage off Merak, Strait Sunda. The description runs as follows:

Test more or less conical, dorsal side often with rather conical top, due to thick layers of hyaline secondary chalk; in cases in which these layers are lacking, the dorsal side much more flattened. Chambers at dorsal side relatively low and short, and the later ones not very much increasing in length; sutures at the initial part indistinct, in the later whorls much more distinct, smooth, rounded and oblique to the margin. Adult specimens with 3 coils, total number of chambers 15-22, number of chambers of last-formed whorl 6-8, with an average of 7. Proloculus diameter 10-25 μ. Small deuteropores only at marginal part of chambers, lacking in initial part; proloculus with protopores only.

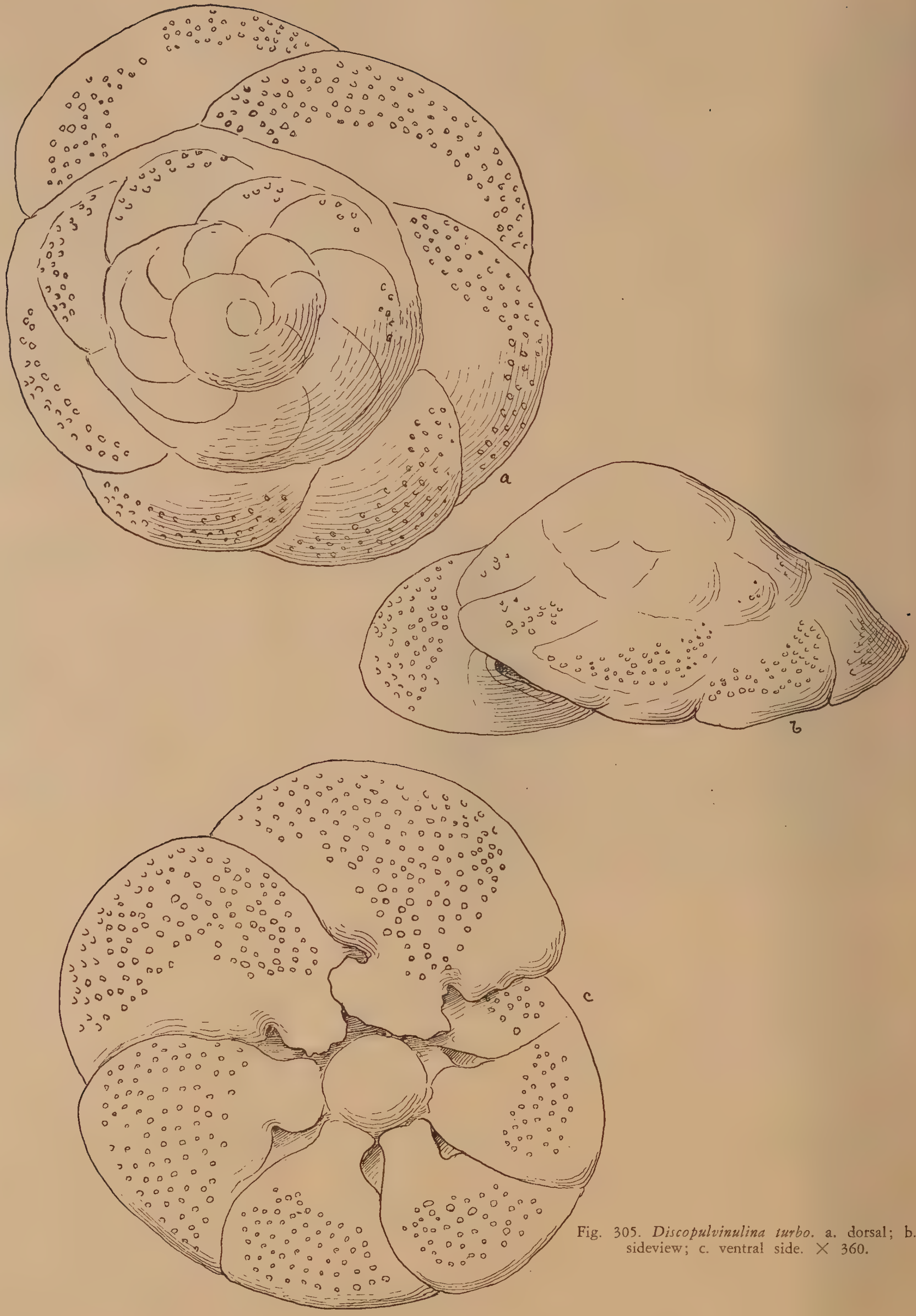


Fig. 305. *Discopulvinulina turbo*. a. dorsal; b. sideview; c. ventral side. × 360.

At the ventral side which is nearly flat or slightly convex, the sutures are nearly radiating, depressed, slightly curving. At each suture a distinct protoforamen remains open, near the umbilical end of the suture. The last formed chamber has its deuteroforamen as a somewhat arched opening near the umbilicus, and between the proto- and deuteroforamen there is a distinct, slightly lobulated lip, extending up to the central umbilical knob; these lips from older chambers fuse with this knob, so that an umbilical opening does not exist in older chambers. Deuteropores over a large area of the ventral side of each chamber, but not in the vicinity of the proximal sutures. Both dorsal and ventral groups of deuteropores leave a narrow but distinct keel without pores at the margin. This keel is seen especially from the ventral side; radiating groves at this keel, as described by Cushman, were not found. Septal foramen a narrow slit at the inner suture, extending nearly over the whole

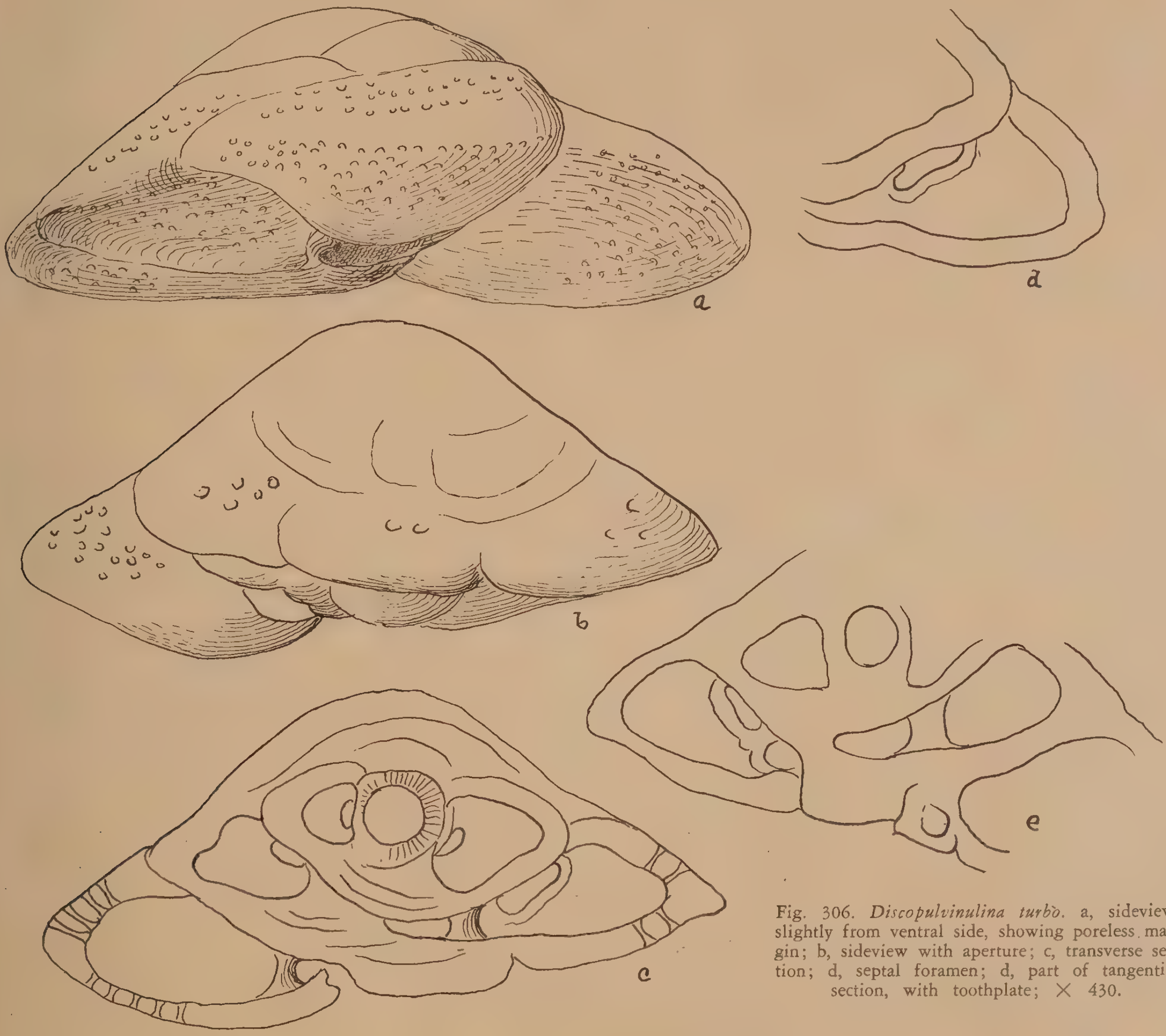


Fig. 306. *Discopulvinulina turbo.* a, sideview, slightly from ventral side, showing poreless margin; b, sideview with aperture; c, transverse section; d, septal foramen; d, part of tangential section, with toothplate; × 430.

inner suture, and provided with a rather distinct thickened lip. The protoforamen shows a small but distinct toothplate which must be regarded as reduced; it is somewhat pillar-shaped.

Diameter of tests 0,18-0,25 mm, thickness of test up to 0,12 mm. The tests are rather translucent.

All these characteristics: open protoforamina in all chambers on ventral side, thickened walls; deuteropores throughout, except for the proloculus, reduced toothplates; hyaline poreless margin, point directly to the genus *Discopulvinulina,* though there are some differences with most other species of this genus. The conical form of the test is misleading, and the central knob does not occur in the *globularis*-group. May be, that this species is a somewhat more ancestral form of *Discopulvinulina* than those species, belonging to the *globularis*-type.

Discopulvinulina pacifica nov. spec.
(Figs. 307-309)

The species has been found at 2° 26′ S., 100° 0′ E., depth 222 fathoms, 1° 51′ S., 99° 36′ E., depth 683 fathoms, St. 213, Saleyer, depth up to 36 m. It was found too at:

9° 17′ S.,	120° 13′ E.,	depth	320 fth.
2° 26′ S.,	99° 35′ E.,	„	582 „
2° 34′ S.,	99° 44′ E.,	„	777 „

and south of Adelaide, Australia.

Description:

Test circular or somewhat elongated in outline, with lobulated margin. Dorsal side slightly convex, ventral side flattened with a distinct irregularly formed umbilicus. Dorsal sutures arched, all chambers visible in microspheric and A_1-specimens, in A_2-forms the first chambers are covered by hyaline secundary chalk. Walls dorsally pierced by very regular and numerous pores, width of pores about 3 μ; proloculus always with very fine pores. Sutures distinct, covered by hyaline secundary chalk. Walls totally hyaline. Margin rounded. Ventral side hyaline, only at the margin covered with the numerous pores. In the B- and A_1-forms the centre of the chamberwalls toward the umbilicus is hyaline without pores at all, or with scattered pores of the same width as dorsally. In the A_2-generation the whole shellwall is ventrally covered with scattered pores, with about a space of 5 μ; whereas dorsally this space is only about 4 μ.

The sutures ventrally are marked by a strongly lobulated habitus, running first from the margin toward the umbilical region, then turning again toward the margin, and once more folding toward the umbilicus, while at last they turn once more toward the margin to form the dorsal border of the aperture. This forms a slit ventrally running up onto the margin.

The species occurs also, but rarely, in the Mediterranean.

Larger specimens often very irregularly shaped. May be, that Cushman's *Discorbis opima* (Contr. For. Res., vol. 9, pt. 4, p. 88, pl. 9, fig. 3) is closely allied to this new species. The figure given by Cushman shows, however, a somewhat thicker form, though the ventral side has nearly the same sutural structure.

The "*Discorbis*" *globularis*-group
(Figs. 310-313)

There are at least four species which belong to this group. They may be geographic subspecies, they may be also distinct species.

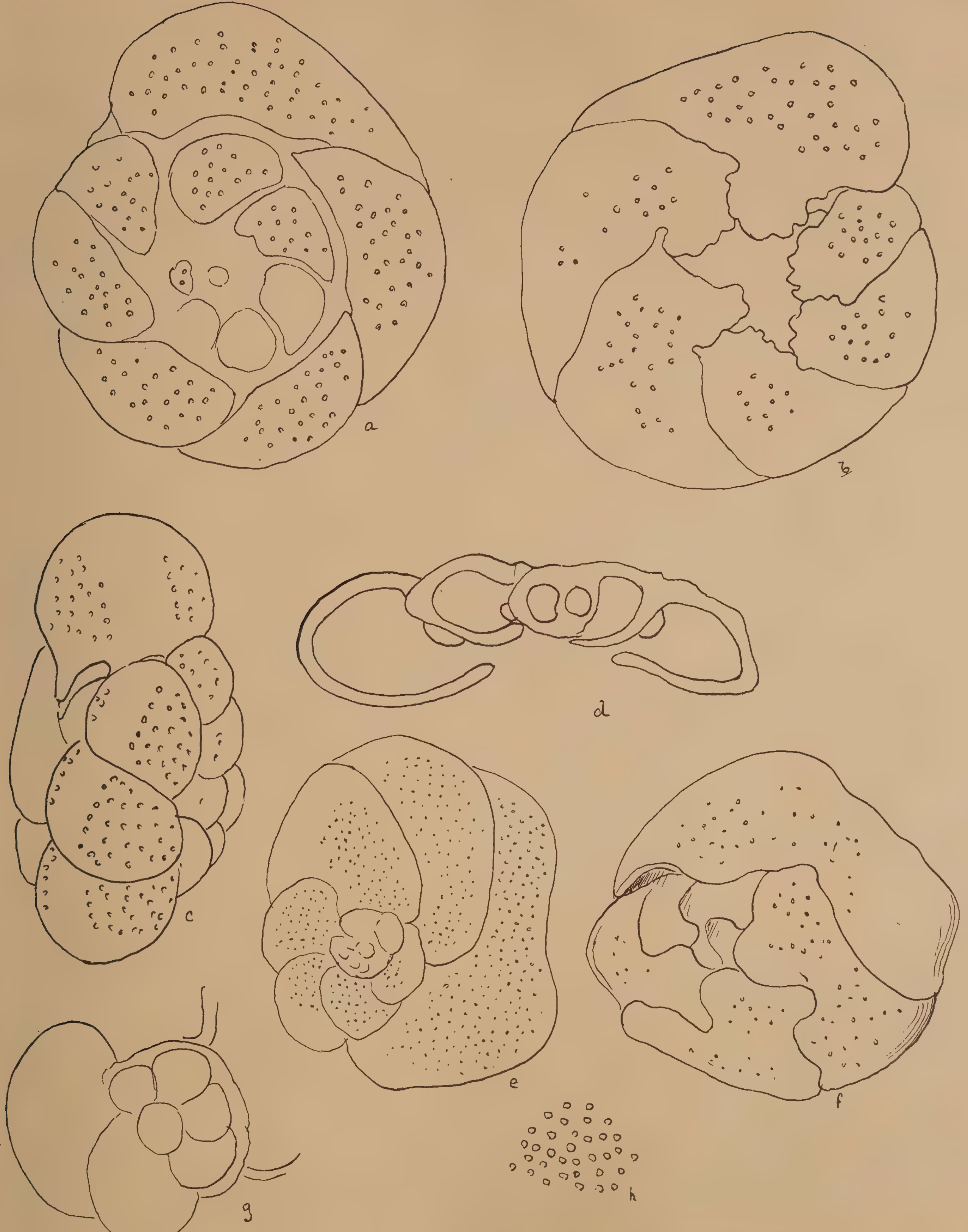


Fig. 307. *Discopulvinulina pacifica.* a, b, c. views of individual, × 430; d, section, × 430; e, f, dorsal and ventral sides of large megalospheric specimen, × 90; g, initial part of it, × 430; h, dorsal pores, × 480.

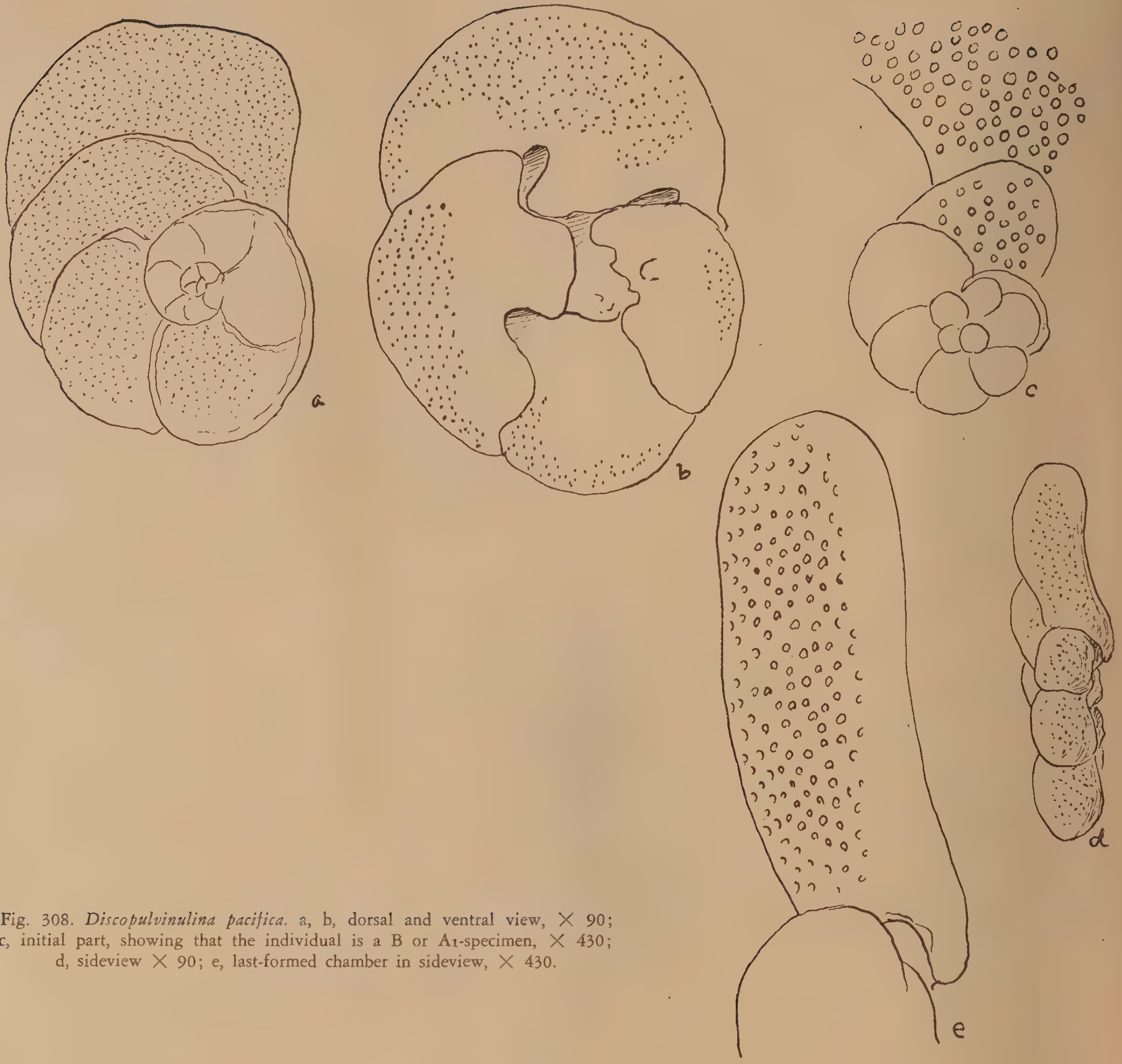


Fig. 308. *Discopulvinulina pacifica.* a, b, dorsal and ventral view, × 90; c, initial part, showing that the individual is a B or A1-specimen, × 430; d, sideview × 90; e, last-formed chamber in sideview, × 430.

In a gathering off Merak, depth about 10 fathoms, a species was found in abundance. The proloculus always is small, though the specimens are obviously not all microspheric ones. The proloculus measures about 10 μ diameter, and is followed by 3-4 whorls of chambers, with about 5 chambers in the last-formed whorl. The dorsal side shows very coarse pores, diameter 8-10 μ, which are, however, nothing else but spots, spared out by the overgrowing secondary shell-substance. This substance forms in the first chambers a relatively thick layer, by which all the fine pores have been covered; in the later chambers at distinct places the test remains thin, and at the bottom of these thin places the fine pores can be seen. In the Merak-species these spots are found at the dorsal side up to the margin, so that from the ventral side at the margin these so-called pores can be seen. At the ventral side no pores at all are visible, the walls here being totally smooth and quite hyaline. They are fairly thickened, and the lips underneath the apertures too are thickened, as to become

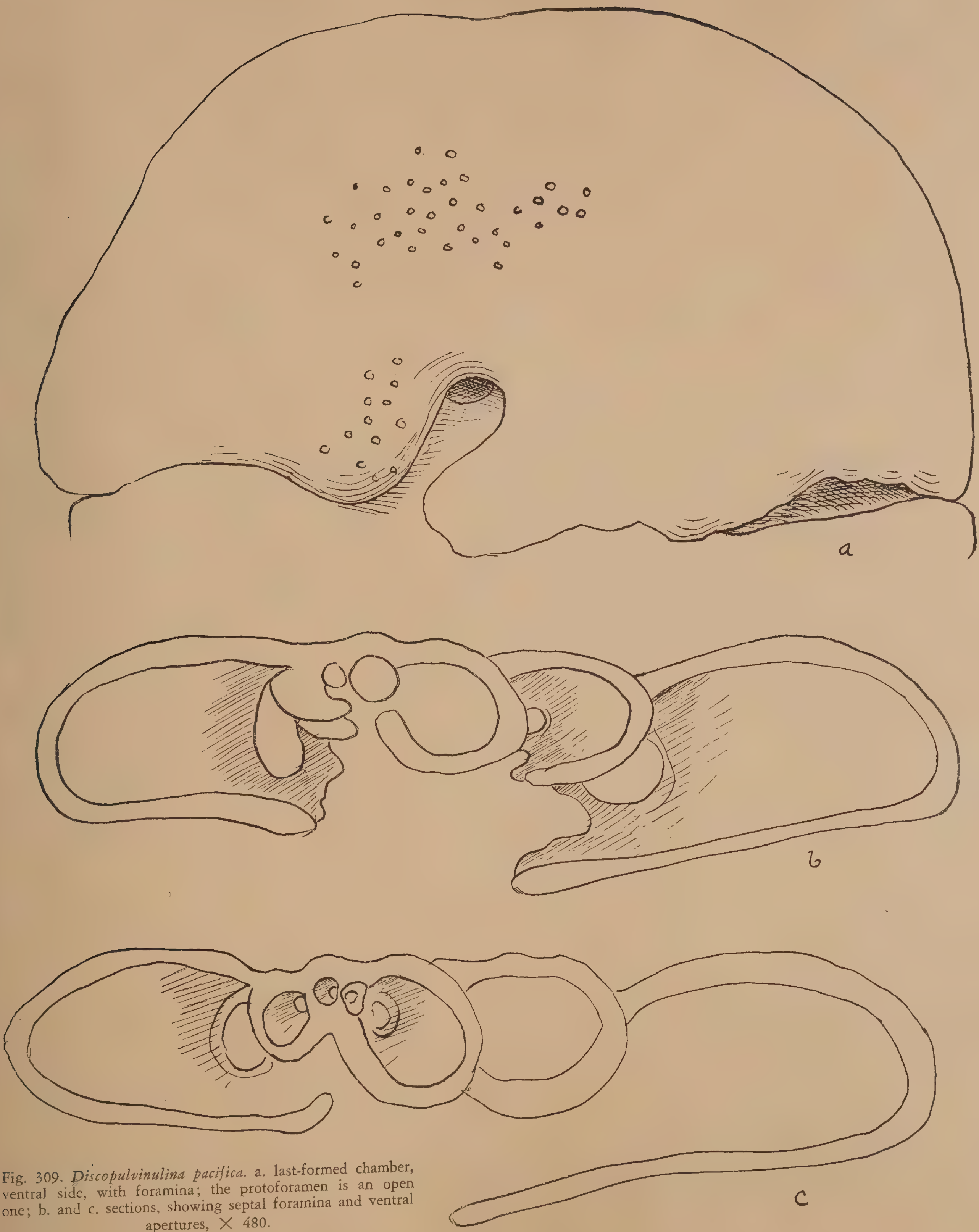


Fig. 309. *Discopulvinulina pacifica.* a. last-formed chamber, ventral side, with foramina; the protoforamen is an open one; b. and c. sections, showing septal foramina and ventral apertures, × 480.

heavy outgrowths, irregularly curving along the sutures. In the umbilical part several knobs of secondary chalk are found.

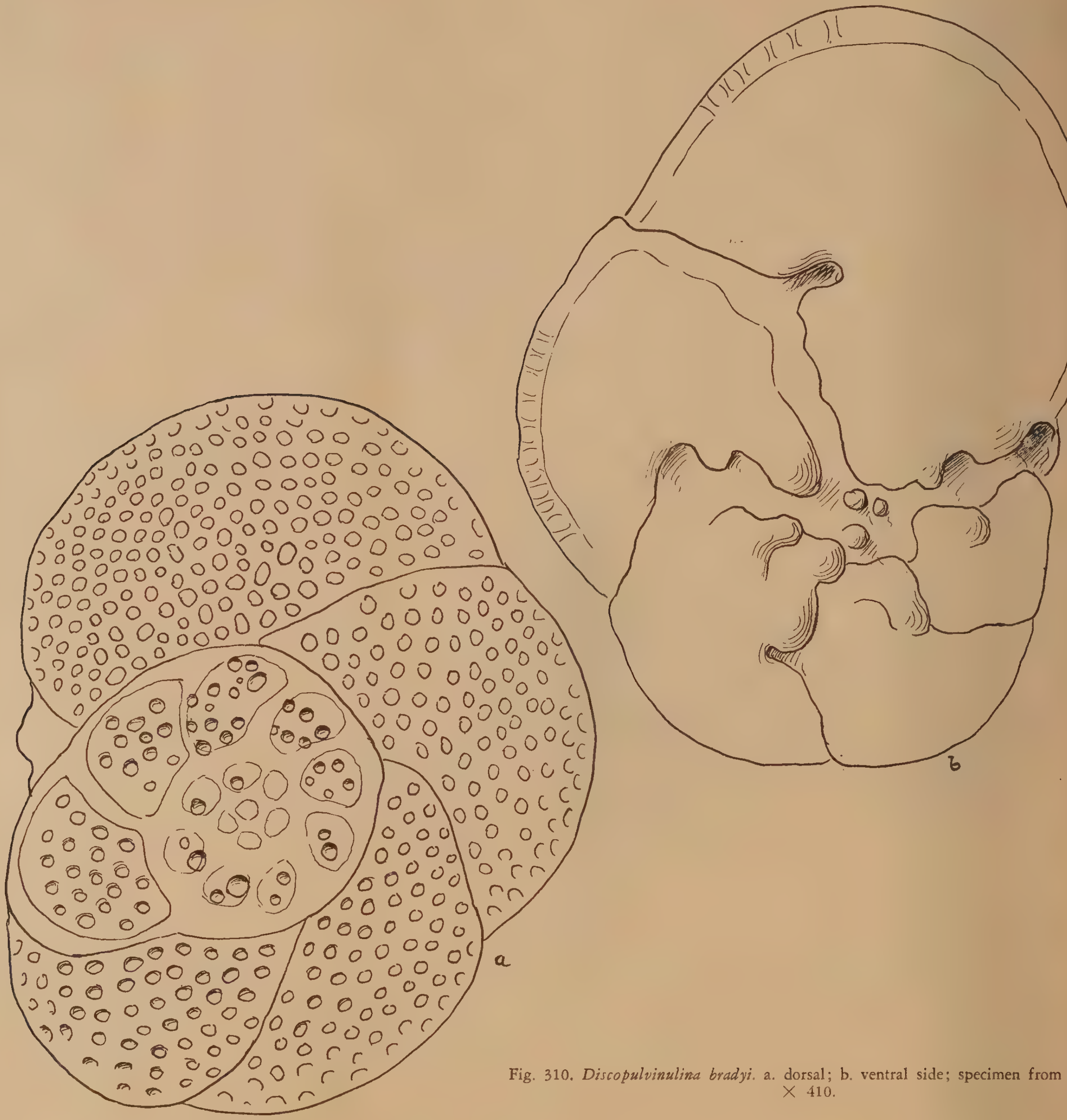


Fig. 310. *Discopulvinulina bradyi.* a. dorsal; b. ventral side; specimen from Merak. × 410.

The aperture begins at the ventral suture just underneath the margin, and then runs toward the umbilical region. When the lip, covering the aperture has nearly reached the umbilicus, it runs straight off toward the opposite margin, suddenly ending in a lobe which forms a peculiar grove in the middle of the chambersuture. This lobe is situated just at the place, where the former aperture of the former chambers is situated, and its inner wall is attached to that aperture. At the marginal part of the aperture a small but distinct chalk-ridge is protruding, the remains of a toothplate, running along the margin. At the margin itself pores are never found. Though there are thus very coarse "pores", in reality the pores are very fine, as in all real *Marginolamellidae.* So the species belongs close to the *Marginolamellidae* without doubt, and has to do with *Conorbis,* as the fissure at the venral proximal suture suggests a homology with that, found in real *Conorbis.* The fissure is nothing but the protoforamen, fastened at the border of the former aperture by a toothplate. (*Discopulvinulina bradyi* (Cushman)).

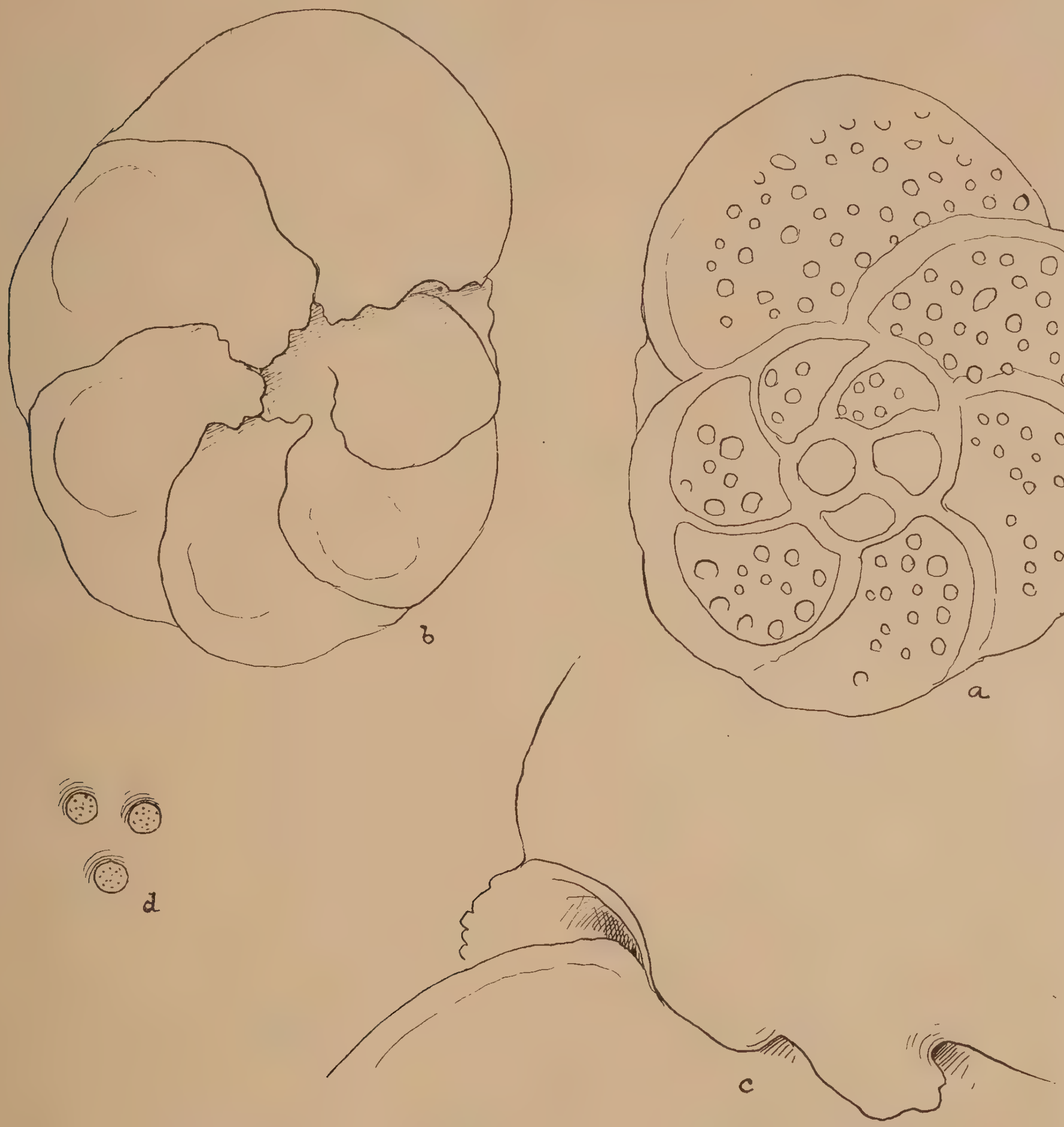


Fig. 311. *Discopulvinulina globularis,* from the English coast. a. dorsal; b. ventral view of small specimen, × 430; c. aperture of large specimen, × 430; d. deuteropores with protopores at their bottoms, × 570.

A second species occurs at the English coasts. In a gathering there are some specimens

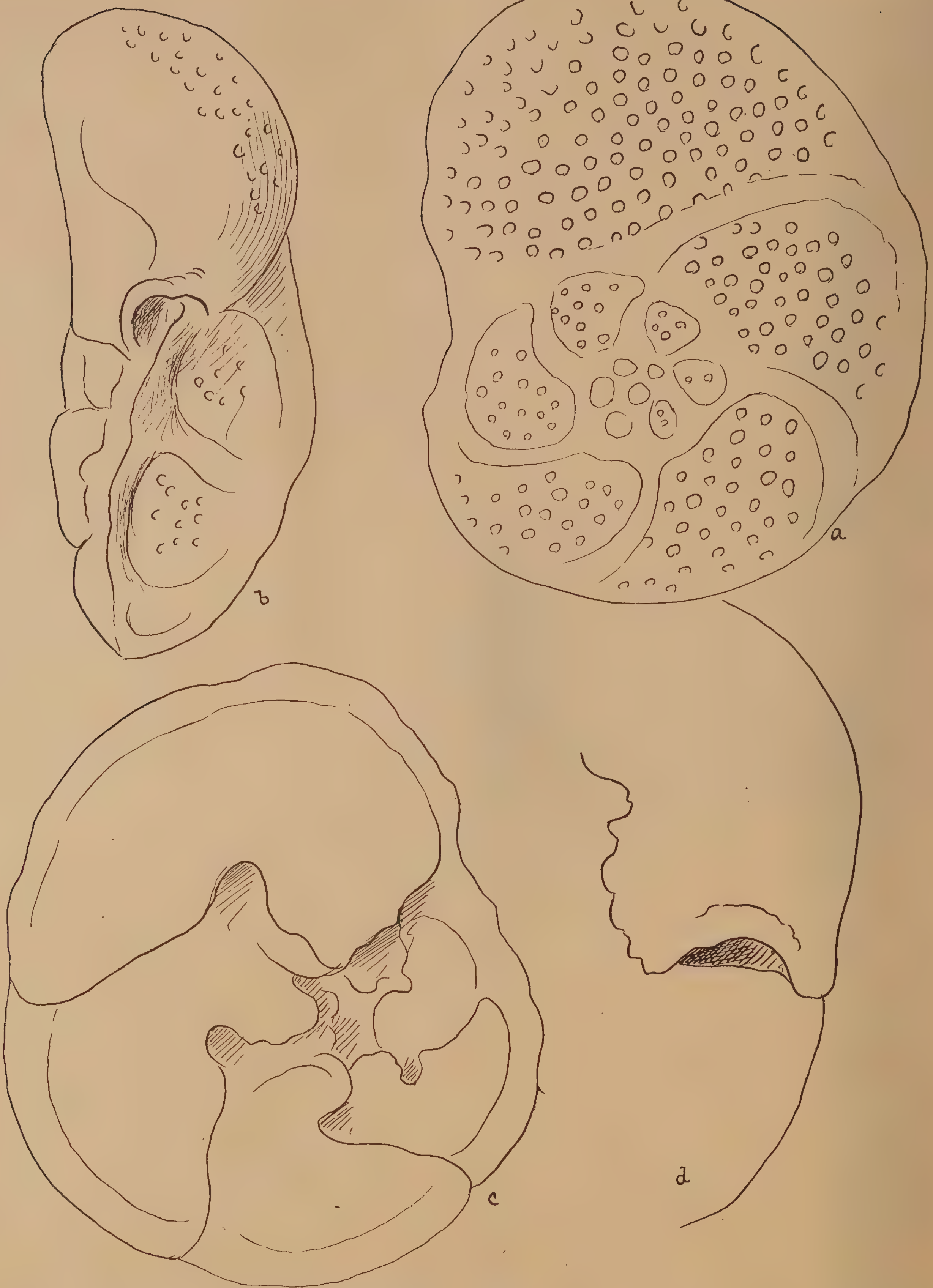


Fig. 312. *Discopulvinulina macropora,* from the Bay of Naples. a. dorsal; b. sideview; c. ventral side of small specimen, × 430 d. aperture of large specimen, × 430.

belonging to the microspheric generation, but most of them show a larger proloculus, measuring about 20-30 μ diameter. This proloculus is followed by 2 or 3 whorls of chambers, 6 chambers in a whorl, which show at the dorsal side the sutures, and the large "pores", as are found in the Merak-species. The pores however, though showing the same diameter, here have larger distances between. At the ventral side the aperture likewise begins at the ventral margin, likewise runs toward the umbilicus, and likewise is covered by an irregular lip which, having reached the umbilical region,

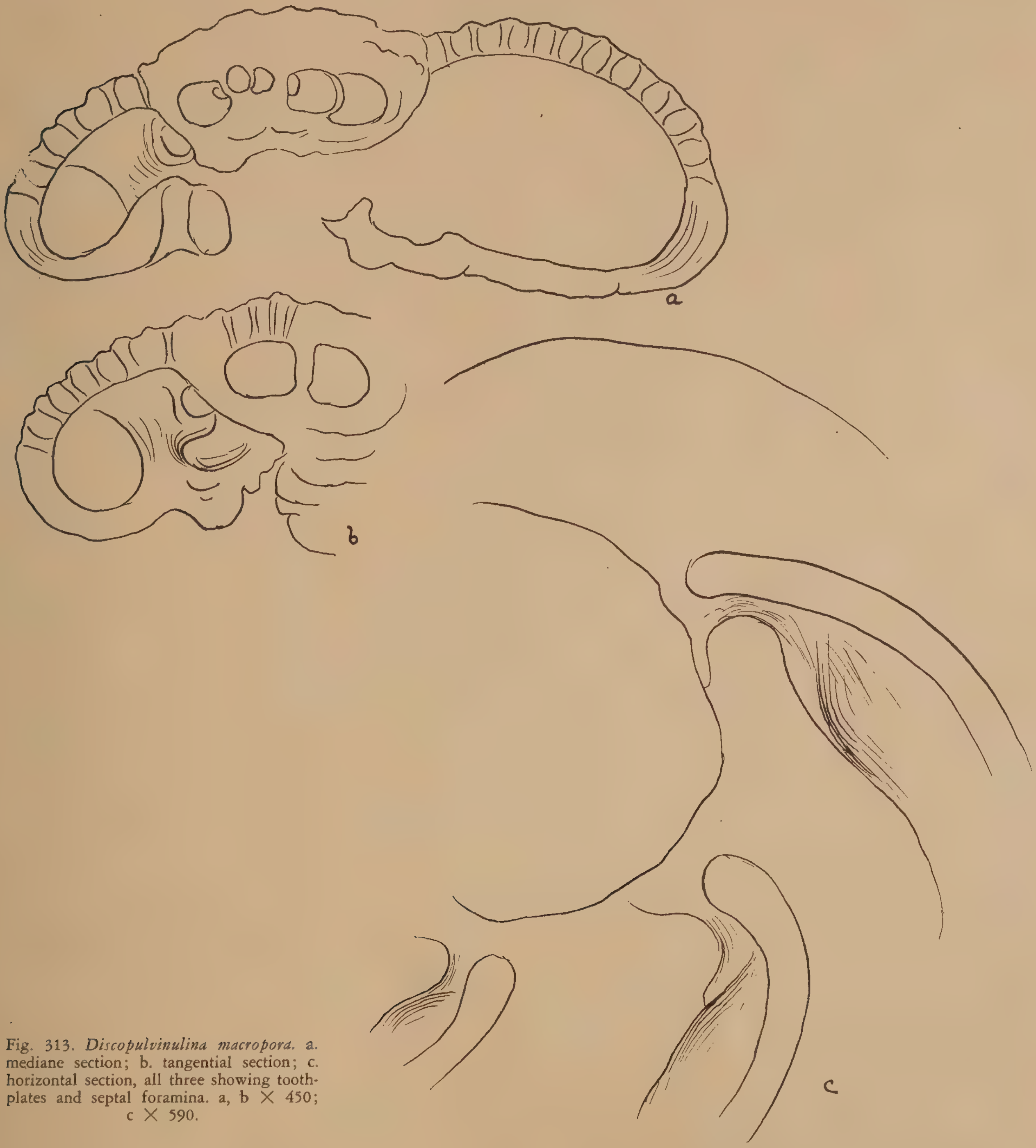


Fig. 313. *Discopulvinulina macropora.* a. mediane section; b. tangential section; c. horizontal section, all three showing tooth-plates and septal foramina. a, b × 450; c × 590.

suddenly runs back to the opposite margin. But it does not end in a distinct fissure underneath the former aperture, or at least this fissure is scarcely visible. The walls at the ventral side are likewise smooth and totally poreless, the lips are not heavily thickened, and there are no knobs of secondary chalk in the umbilical hollow. Moreover, from the sutures secundary chalk has overflown the ventral walls, leaving only a rounded central part free which often can be seen clearly.

At the marginal part of the aperture a distinct, often even heavy tooth is found, protruding at the margin. From this tooth in older chambers the lip underneath the aperture is running, thus indicating that at least this lip, probably also the whole ventral wall, is a toothplate. In this species the so-called "pores" at the dorsal side do not reach the margin, so that when seen from the ventral side, the margin is lacking them. (*Discopulvinulina globuaris* (d'Orbigny)).

A third species is found in the Mediterranean, abundantly in the Bay of Naples. The dorsal side shows heavily thickened sutures and the same arge "pores". They do not reach the hyaline and keel-like margin. At the ventral side the toothplate at the margin is only indicated, the aperture begins at the margin and shows a large lip underneath it. This lip runs toward the umbilical region, and suddenly bends back toward a very conspicuous and clearly seen fissure, where it ends. The suture then runs toward the opposite margin as well. The thickenings of the ventral walls which are likewise hyaline, smooth and poreless, are distinct and heavily lobulated. No chalk-knobs in the umbilical hollow, except in very large and outgrown specimens. Proloculus always very small, as in the Merak species. (*Discopulv. macropora* nov. spec.).

A fourth species was found at several stations in the Archipelago and is distinguished by its much finer pores which, however, likewise are openings spared by the secondary chalk, in which several fine pores open (deuteropores). The species shows very clearly the typical fissure in each ventral suture underneath the septal foramen of older chambers, and at the dorsal side the "pores" are somewhat larger than on the ventral side. Moreover pores are found too at the ventral side, but a clear margin without pores always remains. Sections show, that the septal foramen is situated in the middle or even at the ventral part of the suture. Between the larger "pores" much finer pores are found, especially in the ventral walls; it may be, that those finer pores exist also in the other species, mentioned above, but that they are covered by the thick layers of secondary chalk. It seems, that this species is more primitive than the other species. (*Discopulv. pacifica* nov. spec.).

As type for the genus *Discorbis* is given by Cushman, by designation, *Discorbis vesicularis* Lamarck. This species, however, does not belong to real *Discorbis,* as it belongs to the genus *Cibicides,* with its bulky dorsal side, and its chambers reaching the umbilicus. So it seems, that we have to drop the generic name *Discorbis,* and that we have to look for a different name. These species are very much related to *Pulvinulina,* as I have designed it formerly. They must be closely related to the species which I have called *Pulvinulina binkhorsti* from the Upper Cretaceous. On the other hand they show relations with *Globorotalia* and *Globotruncana.* So I called the new genus *Discopulvinulina.*

Description of the genus will show, that many species, hitherto believed to belong to *Discorbis,* and consequently to be allied to *Conorbis,* are with much more reason classified into the *Marginolamellidae.*

From these four species I measured 12 specimens of each, with the following average results:

	D. macropora.	*D. globularis.*	*D. bradyi.*	*D. pacifica.*
Diameter test × 480 in mm	48	35	25	50

Diam. proloculus × 480 in mm	5,2	11	3,5	6
Total number of chambers.	16	11	17	14
Number chambers last whorl	4	6	5	5
Diameter of pores × 480 in mm	3	2,5	2	1,2

These numbers given are average numbers. Especially larger specimens of *D. pacifica* are irregular, while their tests are much more opaque than those of the other three species.

I give here figures of all four species, though I shall only describe more fully *D. pacifica.*

The *lobatula*-group

In the material of the Siboga and of Mortensen's Pacific expedition two different species occurred which at first hand showed a striking similarity with *Truncatulina lobatula* (Walker et Jacob). They may have been looked at by several authors as such, as no attention was given to the pores. A closer examination, however, showed, that they have nothing to do with *Truncatulina* (*Cibicides*), as the side, at which the chambers meet in the centre, is the dorsal one, and not the ventral, which fact is shown in sections. In the species *Discopulvinulina pacifica* and in *D. auracana* from the West-Indian region the dorsal walls of the chambers show the tendency to overlap the dorsal side. In the species I have to describe now this process of overlapping has reached its utmost development, as in these species the chambers meet in the centre of the dorsal side, thus covering all chambers of former coils. In this way a kind of test is formed, which closely resembles that of *Truncatulina,* but for the fact, that the meeting parts of chambers are situated on the dorsal side, that the pores are protopores and no deuteropores as is always the case in real *Truncatulina* (*Cibicides*) and that at the ventral side traces of a protoforamen are still visible. In real *Truncatulina* the aperture creeps up to the margin and even overgrows this margin so as to form an apertural opening at the dorsal side. In the *lobatula*-group of *Discopulvinulina* the aperture is situated under the margin and shows a distinct lip at the ventral side, very much like the dorsally placed part of the aperture in *Truncatulina* (*Cibicides*). So a confusion with *Truncatulina* is very probable and it may be, that several authors, dealing with these species of *Discopulvinulina,* have thought them to belong to *Truncatulina lobatula.*

There are but few references known of *Truncatulina* (*Cibicides*) with fine pores. I will quote here the following species: *Planulina caribbea* Cushman (U.S. Nat. Mus., Bull. 104, pt. 8, 1931) which without doubt is a *Discopulvinulina,* as even in the figure the protoforamen at the ventral side is visible; *Cibicides refulgens,* of which the fact, whether the species possesses protopores is not yet solved; *Cibicides concentrica,* which I could study in the material from the West-Indies, and which proved to be a real *Discopulvinulina*; *Cibicides robertsoniana,* the place of which seems doubtful (all species cited above from Bull. 104, pt. 8). There are many records of fossil *Cibicides* with fine pores; they all have to be restudied, as even in cretaceous real *Cibicides* (*Truncatulina*) the pores are of the deuterotype.

I called the species, hereafter mentioned, the *lobatula*-group, as I believe, that several species of that group have been looked at by former authors as *Cibicides lobatula,* as they resemble in general features that species.

There may be some reason to give a special generic name to those forms of *Discopulvinulina,* in which the chambers overlap on the dorsal side in such a way, that they meet at the centre of the test. But I may point out, that some species of *Discopulvinulina* already show the tendency to overlap, and that intermediate stages are found (*Discopulvinulina araucana* e.g.). So I did not give a new generic name as yet.

Discopulvinulina pseudolobatula, nov. spec.
(Figs. 314-317)

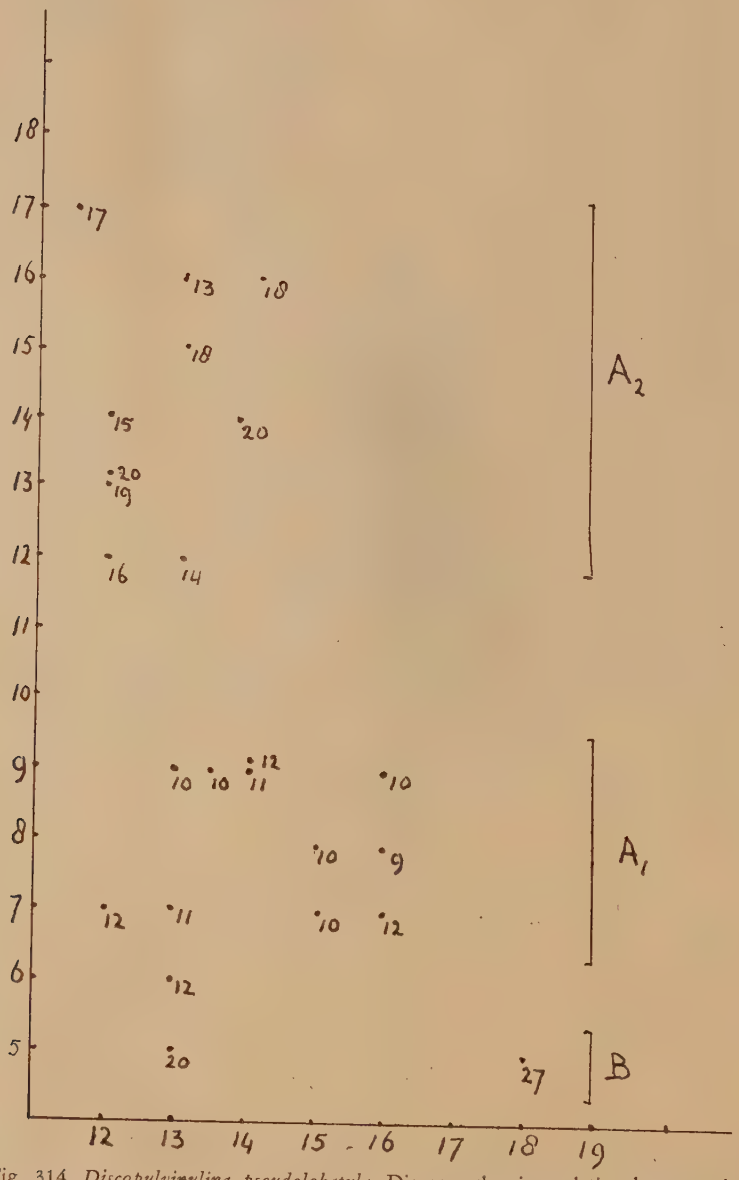


Fig. 314. *Discopulvinulina pseudolobatula.* Diagram showing relation between size of proloculus and ratio between length and breadth of test; figures added designate the total number of chambers. Three distinct groups could be traced, all from one station.

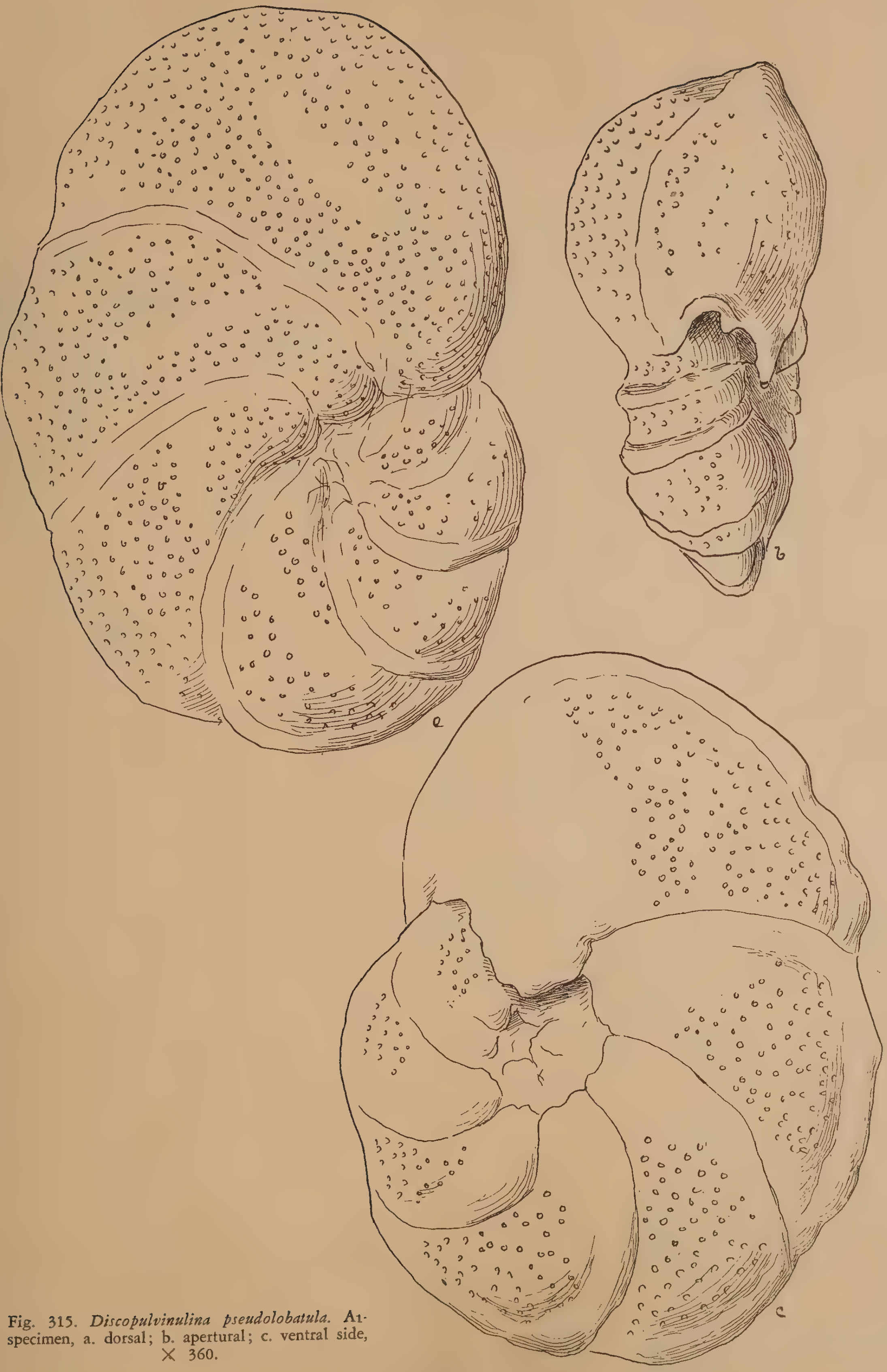


Fig. 315. *Discopulvinulina pseudolobatula.* A1-specimen, a. dorsal; b. apertural; c. ventral side, × 360.

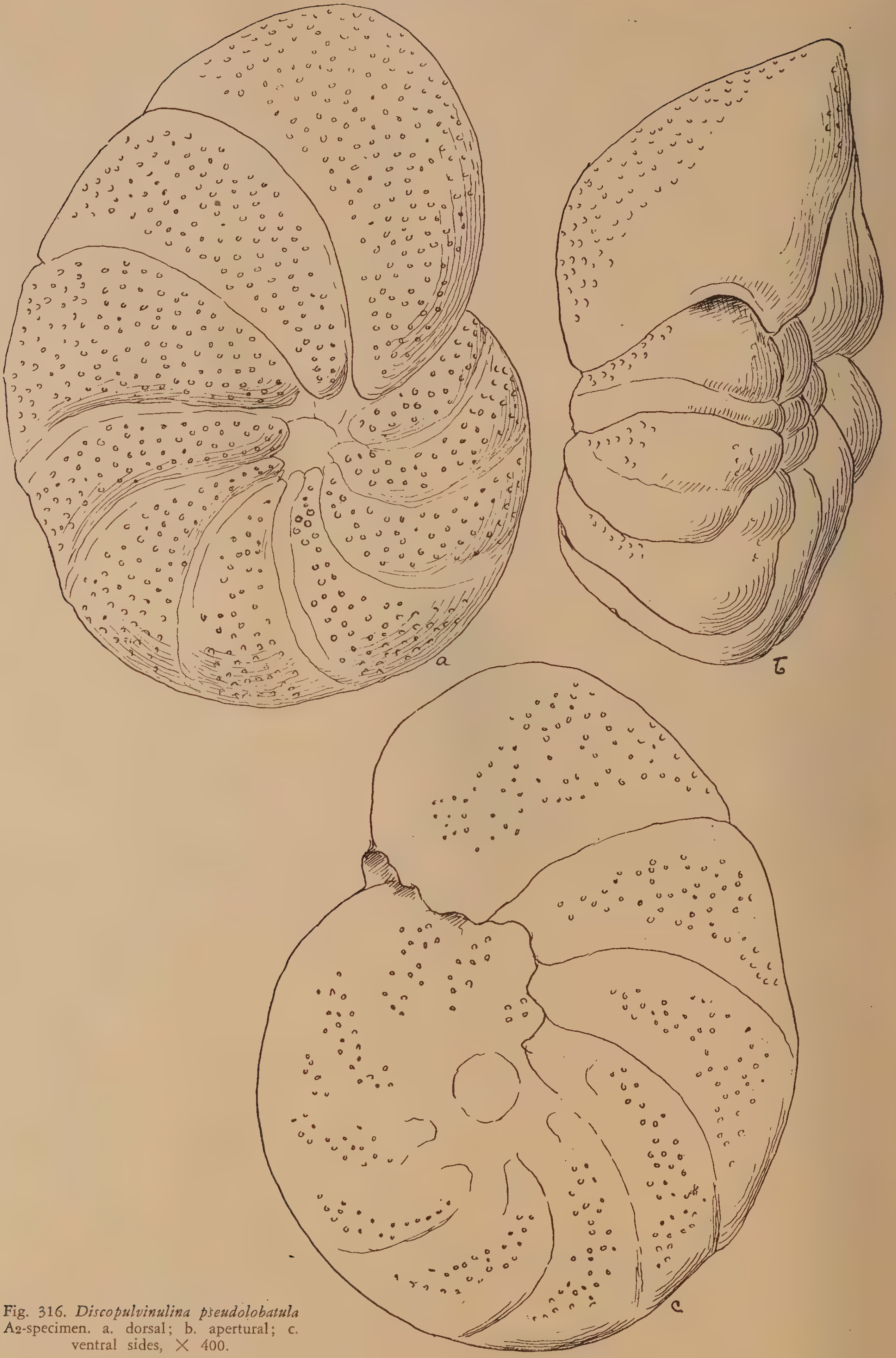


Fig. 316. *Discopulvinulina pseudolobatula* A2-specimen. a. dorsal; b. apertural; c. ventral sides, × 400.

The species was only common at St. 5° 21′ S., 107° 14′ E., depth 43 fathoms. It differs from *Cibicides lobatula* in the finer pores and the hyaline test.

Moreover the species was found at St:

2° 56′ S., 99° 58′ E., 405 fathoms.
St. 213, Saleyer, 5-19 fathoms (common).
Tunganan-bay, Philippines.

Description.

B-generation. Test longer than broad (relation between length and breadth about 1,6). Later chambers rapidly increasing in height. Chambers 20-27 in number, 7 or 8 in the last-formed coil. The dorsal side is the convex one, as is shown in transverse section. Proloculus about 10 μ diameter. A hyaline carina, rounded, is surrounding the test, while the sutures are somewhat protruding by secondary chalk, which is hyaline and without pores. Pores rather coarse, but not deuteropores; dorsally they cover the whole surface of the chambers, except for a more or less developed ridge transversally running over the chamberwall; ventrally they cover only the marginal and initial part of each chamber. Sutures somewhat curved. At the ventral side the ventral deuteroforamen is covered by a large hyaline lip, irregularly shaped at its margin, as in most Discopulvinuline shells. Transverse section shows the proloculus situated toward the convex dorsal side, the septal foramen situated ventrally just under the margin, and the aperture beginning just ventrally from the septal one. In the first coils this ventral aperture is closed by the secundary chalk, filling up the flat umbilicus. The protoforamen on the ventral side is nearly totally absent. Length from 0,28-0,35 mm; breadth about 0,23 mm.

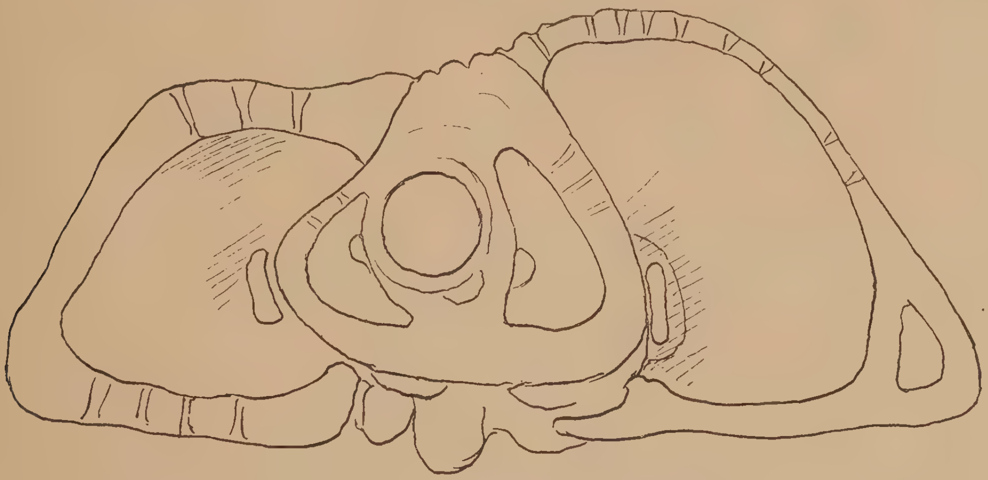


Fig. 317. *Discopulvinulina pseudolobatula.* Section through A_2-individual showing the situation of proloculus and that of the septal foramina. × 480.

A_1-generation. Shows the typical features of B, only the secundary chalk in the umbilicus and on the sutures is somewhat more developed.

Length from 0,25 up to 0,35, breadth about 0,20 mm.

A_2-generation. This generation differs from the other two in a much more rounded periphery, not elongated shells, chambers not very rapidly increasing in height, while the total number of chambers is larger than that of the A_1-generation which is a peculiar fact. In the A_1-generation the total number of chambers ranges from 10-12, and the number of chambers in the last formed whorl is about 7. In this A_2-generation the total number of chambers ranges from 13-20, and the number of the last-formed coil is about 10. The ratio between length and breadth in these shells is about 1,2, and not about 1,6, as it is in the A_1- and B-generations. But all other characteristics, the width of the pores (about 1,5 μ), the texture of the shellwalls, the sutures, the shape of the apertures, etc. are alike.

The species has nothing to do with *Cibicides,* but is a real pulvinuline shell, with its ventrally open apertures.

Discopulvinulina hyalina nov. spec.

(Figs. 318, 319)

A single, megalospheric specimen with proloculus diameter of 17 μ, was found at Station 2° 17′ S., 99° 27′ E., 377 fathoms and at St. 5° 21′ N., 107° 14′ E., 43 fathoms. Many specimens were found at Little Barrier Island, New Zealand, depth 30 fathoms. It belonged to those Foraminifera which show externally the characteristics of *Truncatulina,* with one side flattened, the other inflated, while the aperture seems to be an arched slit near the margin which is very sharp, while this aperture extends along the spiral sutures of the last formed chambers. In these forms the pores are small and the shell-material is hyaline, while he umbilicus is totally filled up by the ventral lobes of the chambers, and not with hyaline or opaque chalk-material, as is the case in those with coarse pores.

A study of the interior of the specimen showed, that the flat side has to be looked at as the ventral one, while the bulky side is the dorsal side. This was found by the position of the first chambers, surrounding the proloculus, which directly show that they are situated with their ventral outgrown sides towards the flat side of the shell. When this flat side is the ventral one, one at once becomes aware of the fact, that those lengthenings of the aperture by no means are in connection with the real septal aperture, but that they are separated from them. They are nothing else but the ventral foramina, as they are found in all Discopulvinuline tests. But, as the umbilicus is flattened in these attached shells, in such a way, that one can hardly speak of an umbilicus, those ventral foramina, in normal *Discopulvinulina* opening into the umbilical space, now open along the sutures of the chamber, directed towards the centre of the shell.

In real *Cibicides,* contrary to the description by Brotzen, the aperture never shows such a sutural development; real *Cibicides,* moreover, always shows very coarse pores.

Genus **Conorbella** nov. gen.

This genus is characterised on the surface by radiate ornamentations at the ventral side. Some species are conical, with a more or less sharpened initial end; the aperture is a small, more or less rounded opening at the ventral suture of the last formed chamber, situated near the umbilical part. The umbilicus is closed by chalk material. Originally the pores are rather fine, but species with larger pores at the dorsal side (which are, however, protopores as well) are found too. The septal foramina are formed by the aperture, and situated close to the axis.

There are slight indications of toothplates, but no protoforamina. Many fossil and recent forms, described as *Discorbina* or *Discorbis,* in reality are belonging to this new genus. The dorsally placed septal foramina point to a relationship with *Neoconorbina.* Species such as *Discorbis petalifera* (Howe) evidently belong to the genus, as well as *D. corrugata* Millet, which species was found in the Malay Archipelago.

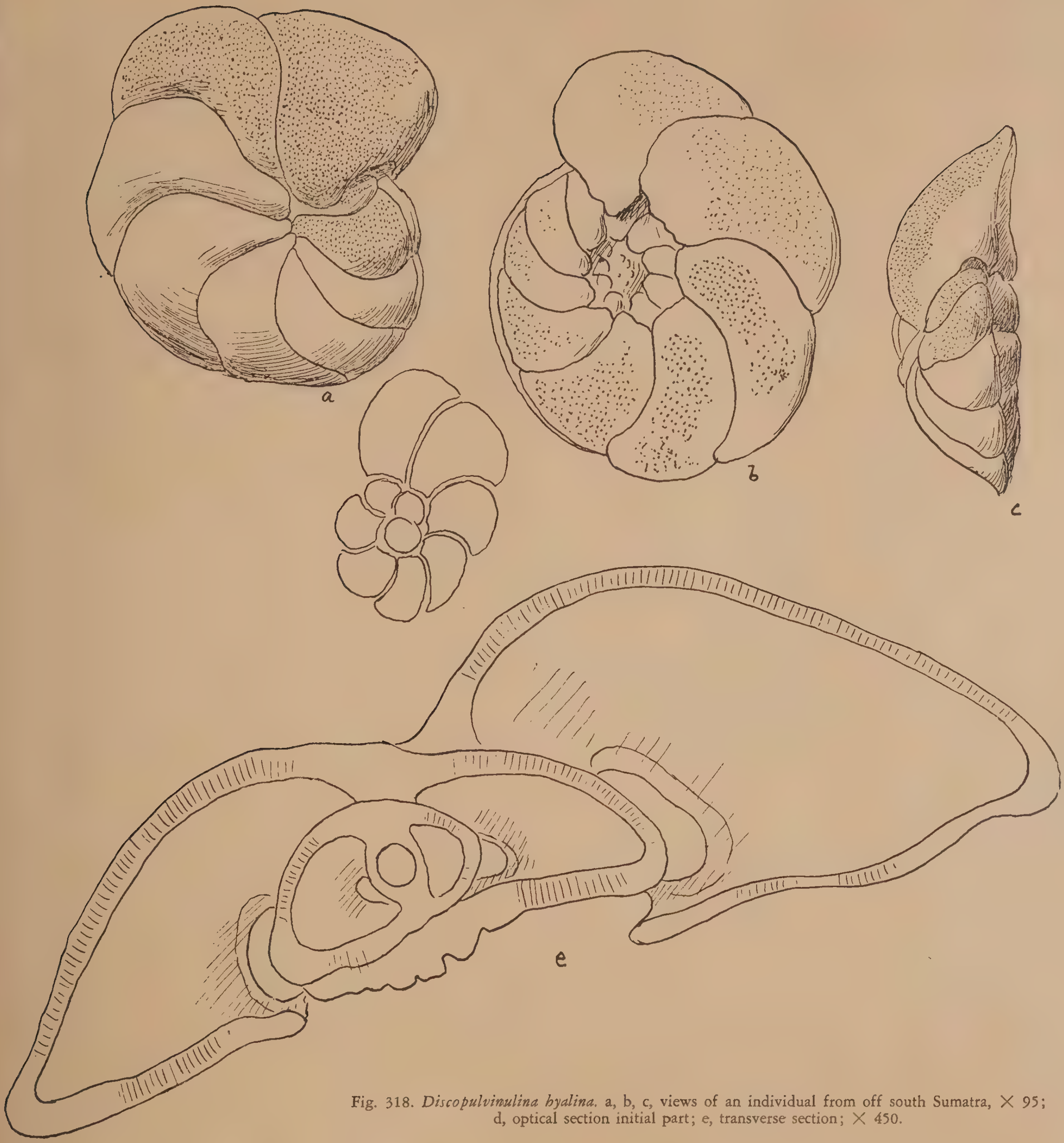


Fig. 318. *Discopulvinulina hyalina.* a, b, c, views of an individual from off south Sumatra, × 95; d, optical section initial part; e, transverse section; × 450.

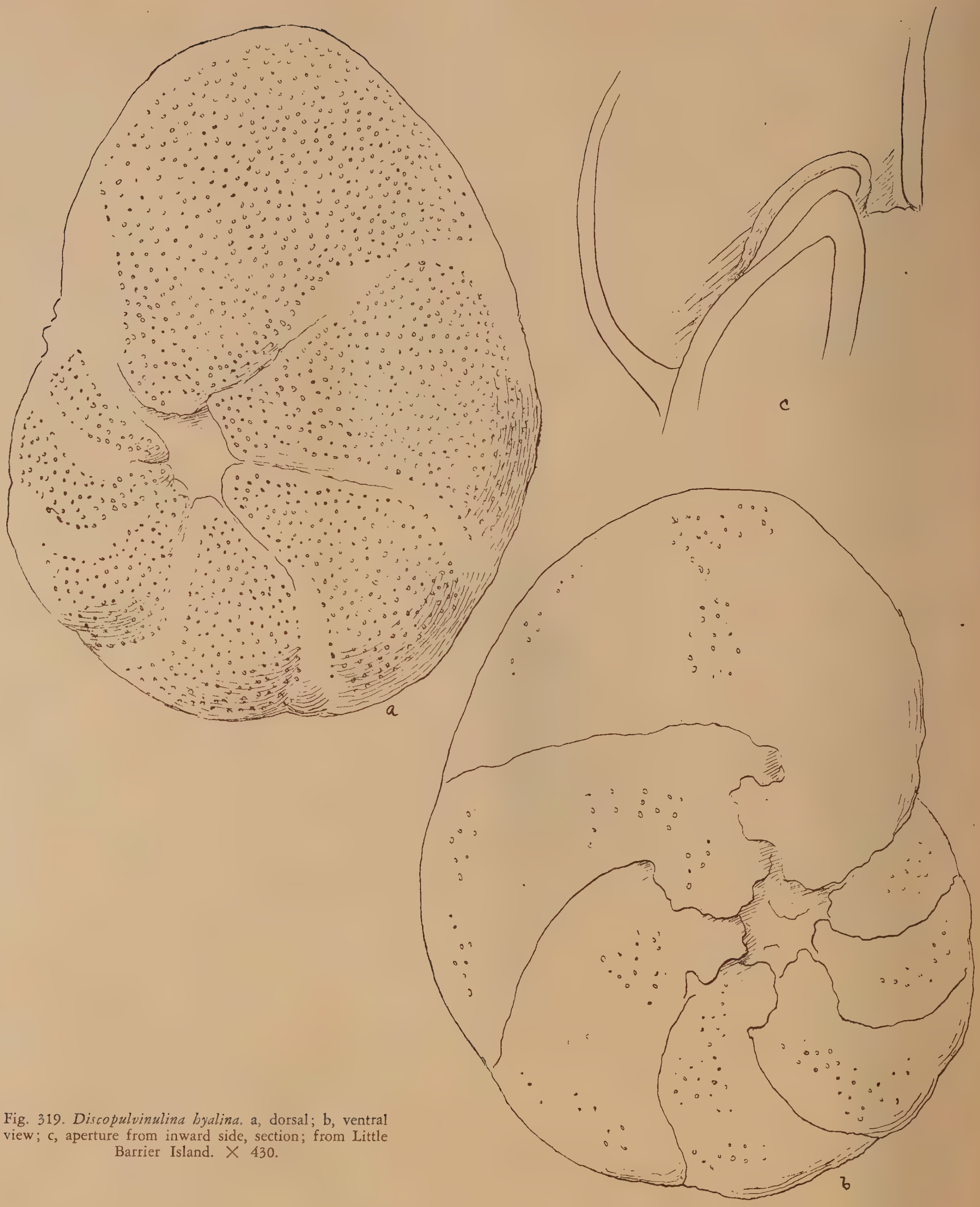


Fig. 319. *Discopulvinulina hyalina.* a, dorsal; b, ventral view; c, aperture from inward side, section; from Little Barrier Island. × 430.

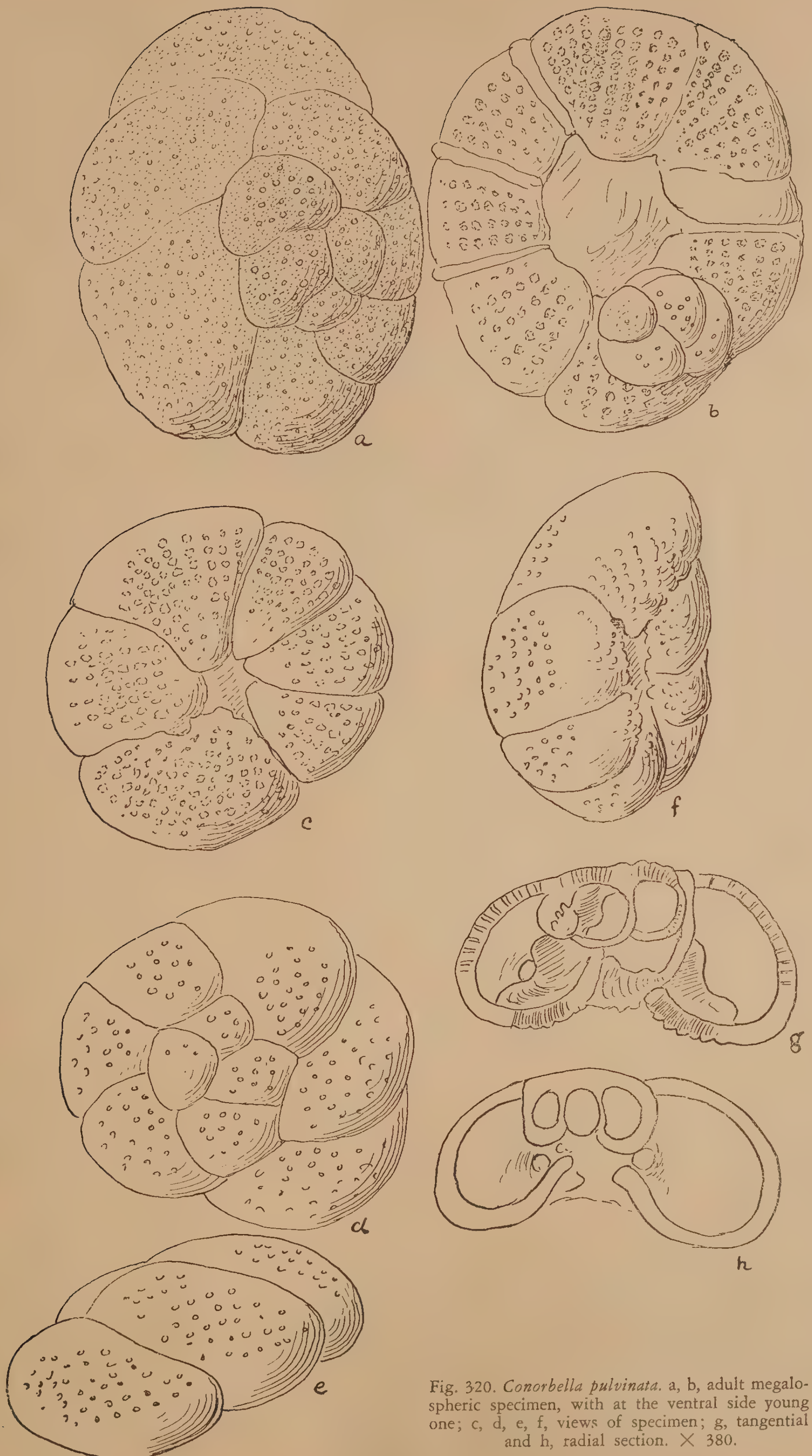


Fig. 320. *Conorbella pulvinata.* a, b, adult megalospheric specimen, with at the ventral side young one; c, d, e, f, views of specimen; g, tangential and h, radial section. × 380.

The type of the genus is *Conorbella pulvinata* (Brady). To this new genus are belonging without doubt several species, now known as *Discorbis* (*Discorbina*), e.g. *Discorbina pyramidalis* Heron-Allen et Earland (Linn. Soc., Journ., Zool., vol. 35, p. 634, pl. 37, figs 56-61, 1924), *Discorbina laurieri* Heron-Allen et Earland (ibid., p. 633, pl. 36, figs. 50-52), *Discorbina elegantissima* Sidebottom (Manch. Lit. Phil. Soc., Mem. Proc., 1908, vol. 52, no. 13, p. 16, 5, fig. 8a-c), *Discorbis byramensis* Cushman (U.S. Geol. Surv., Prof. Paper, 1922, p. 96, pl. 19, figs. 6-8), *Discorbis tuberculata* var. *australensis* Chapman, Parr et Collins (Linn. Soc. London, Journ. Zool., 1934, vol. 38, no. 262, p. 563, pl. 8, fig. 9).

Conorbella pulvinata (Brady)
(Fig. 320)

This species, known hitherto as *Discorbina* or *Discorbis pulvinata* Brady, was found in several specimens in a gathering off Huasco, Chile, and has furthermore been described by Brady from South Sea Islands. So it is a typical Pacific species, and therefore I mention it here.

At the dorsal side the chamberwalls are somewhat overlapping, thus confusing the original spiral arrangement of the first chambers. At the ventral side it shows the radiate sutures of the chambers, mostly leaving free a narrow umbilicus. At the dorsal side two kinds of pores are found in the walls, very fine ones, protopores, and coarser ones, deuteropores. At the ventral side only protopores are found, arranged on slightly protruding tubercules forming radiate rows. At the last suture a small, nearly round aperture is found near to the margin, ventrally.

I met with a specimen, at whose ventral side a small young individual was adhering, possibly a reproduction stage, as is found in many species of the *Conorbine* type. May be, that these youngsters originate from budding.

Sections showed, that there are much reduced toothplates in the chambers, running as in real *Discobolivina* or *Conorbis*. The septal foramen is situated at the ventral part of the inner sutures. Only megalospheric specimens were met with.

Diameter of adult up to 0,20 mm, thickness of test 0,09 mm.

The colour of the walls is, as in *Discorbis,* yellowish.

Conorbella tabernacularis (Brady)
(Fig. 321)

This species, hitherto known as *Discorbina tabernacularis* Brady, was found in a single species at St. 2° 21′ S., 99° 48′ E., depth 460 m, bottom temp. 7,9° C. It has been recorded from Honolulu and from Laysan.

The conical test is built up by a spiral of flattened chambers, showing distinct and clear sutures, whereas the walls of the chambers have very fine pores. The base of the cone is concave, with a deep sunken umbilicus filled up with chalk, and radial rows of protopores, arranged in tubercules. 6 chambers form the last formed coil at the base. Irregular costae run from the apex toward the middle of the test downward. They are quite hyaline.

Section showed traces of a toothplate, and round septal foramina placed at the axis of the cone. The aperture at the base is situated near the umbilicus.

This species seems to be a more ancient form than *C. pulvinata.* The round septal openings at the axis and the protopores, together with the radiate ornamentation on the ventral side, are the main characteristics which indicate the genus *Conorbella.*

Height of cone 0,19 mm, diameter of base 0,17 mm.

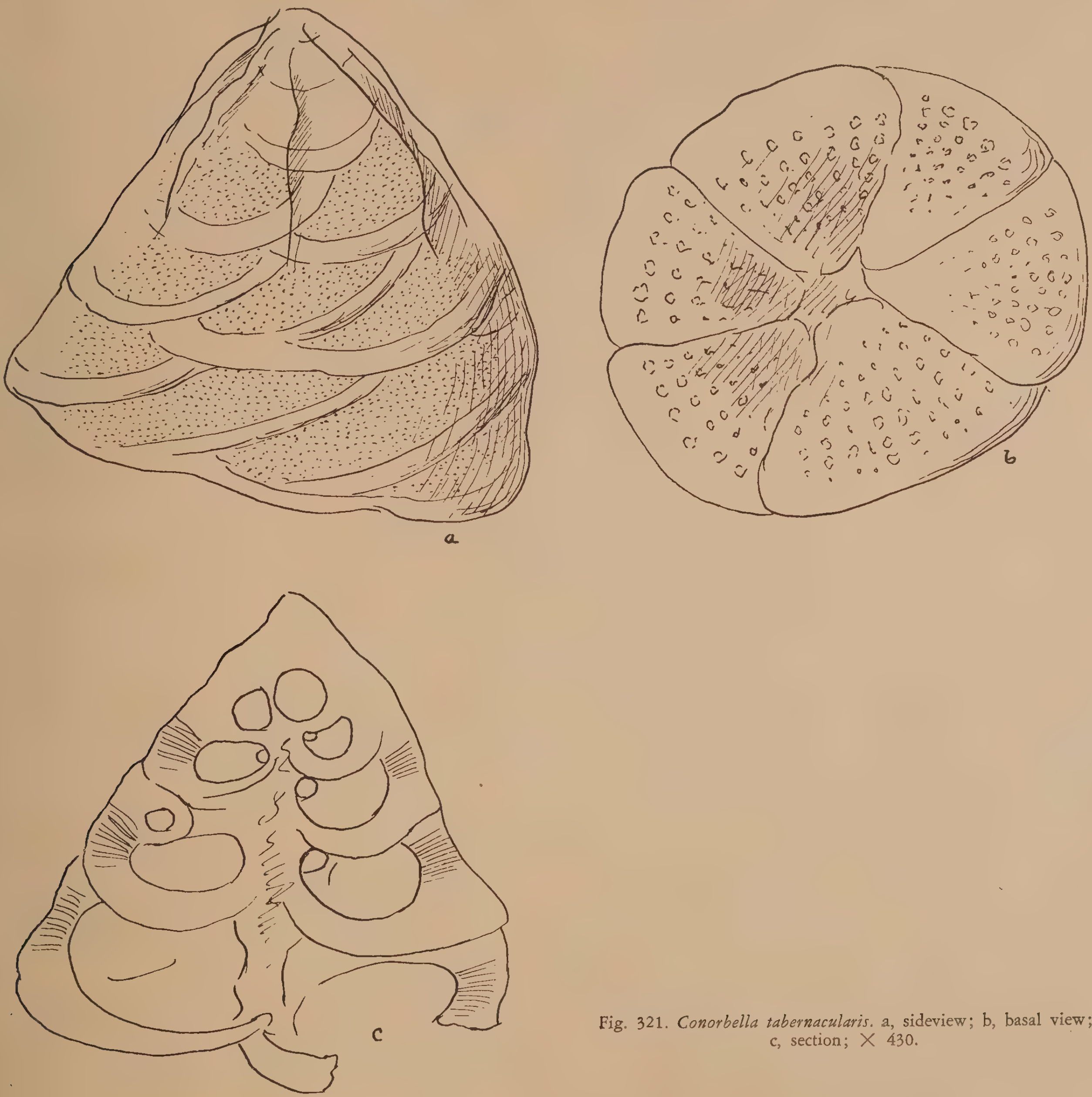


Fig. 321. *Conorbella tabernacularis.* a, sideview; b, basal view; c, section; × 430.

May be that our species is identical with what has been called by Chapman *Discorbina acuminata* from Funafuti Atoll. (Linn. Soc. Journ. 1902, vol. 28, p. 285, pl. 36, fig. 3). But he describes the inferior face as "deeply sunken", which does not agree with our species. He mentions: "Although *D. acuminata* is related to *D. tabernacularis* Brady, it differs in having straighter and longer sides to the cone and a pointed aboral "extremity". The species seems to be related also to

"*Discorbina erecta* Sidebottom from Delos, as here the basal side is likewise provided with the very typical radial ornamentations (Manch. Lit. Phil. Soc., Proceed., 1908, vol. 52, no. 13, p. 16, pl. 5, figs. 6-7).

Genus **Asterigerinata**

This genus, which has been created by Bermudez for the species *A. dominicana,* is closely allied to *Conorbis,* but also to *Asterigerina.* The development of deuteropores, especially on the dorsal side, points to *Neoconorbina*; the possession of protopores on the ventral side points to *Conorbis.* The situation of the toothplate indicates its close relationship with *Asterigerina*; the closing of older protoforamina by a distinct plate points to *Reinholdella.* But this plate is not, as in *Reinholdella,* totally similar to the walls of the chambers, with protopores, but shows a very typical difference with the chamberwalls, as these walls at the ventral side bear fine protopores, whereas those closing plates show very large rounded openings, scattered over the plate. A closer examination shows, that those covering plates are outgrowths of the toothplate itself, and that the rounded openings consequently are toothplate pores. Hitherto only the species *Asterig. mamella* from the English coasts and the Mediterranean and *A. dominicana* from the Tertiary are known. I have mentioned this genus in this Pacific work to emphasise the difference with genera as *Asterigerina* and *Reinholdella,* and as the large material enabled me to give a statistic analysis, which may be an instance for the whole family of the *Conorbinidae.*

Asterigerinata mamilla (Williamson)

(Figs. 322-326)

This species is abundant in the Bay of Napels, as well as off the coasts of England. From both localities I had plenty of material, and the specimens of both are quite identical.

The figures from this species, given in most of the textbooks on Foraminifera, however, do not give the typical characteristics of this very remarkable species. They mostly are drawn from the figures, given by Williamson, and these are not at all correct. Especially the ventral side of Williamson's drawings is much too superficial, and thus its most valuable features seem to have been unregarded by authors.

A statistic study of 84 specimens from the Bay of Napels showed me, that this species is a very beautiful instance of trimorphism. Most of the specimens belong to the A_2-generation, showing a proloculus ranging in diameter from 18 to 31 μ, with a distinct top at about 22 μ inner diameter. These A_2- specimens show a number of chambers following the proloculus, ranging from 10-15. 67 specimens belonged to this generations. 39 of these specimens had only 10-13 chambers; their diameter ranged from 0,18 to 0,25 mm; I regard them to be young specimens. 28 of them had a diameter of the test ranging from 0,24 to 0,30 mm, the number of chambers following the proloculus being 12-15. They represent the adult form.

10 specimens were found, showing an inner diameter of the proloculus ranging from 10-15 μ, with a top at about 13 μ. They showed 12-16 chambers. Individuals with a diameter of test from 0,18 to 0,25 mm were regarded at as being young ones; 7 specimens showed this diameter, with 12-14 chambers. 3 specimens had a diameter of test from 0,24-0,30 mm, with number of chambers ranging from 14-16. This group belongs to the A_1-generation.

Seven specimens had a proloculus with inner diameter of about 6-7 μ only. Of these specimens 3 were youngsters, with a diameter ranging from 0,16 to 0,25 mm; they had 15, 17 and 17 chambers. 4 specimens were adult ones, their total diameter ranging from 0,22 mm to 0,25 mm, thus nearly identical in diameter. These specimens showed 20-22 chambers following the proloculus. This is the adult form. They were all characterised by a large opening in the ventral wall of the last-formed chamber, which opening showed typical smooth borders, so that obviously it has been formed by resorption of the testwall. This may indicate the forming of plasmodiospores, leaving the parental test by this opening; they may have been copulating specimens. In one of the specimens some of those spores, with two chambers, were found within the last-formed chamber, showing the diameter of proloculus of the A₁-generation.

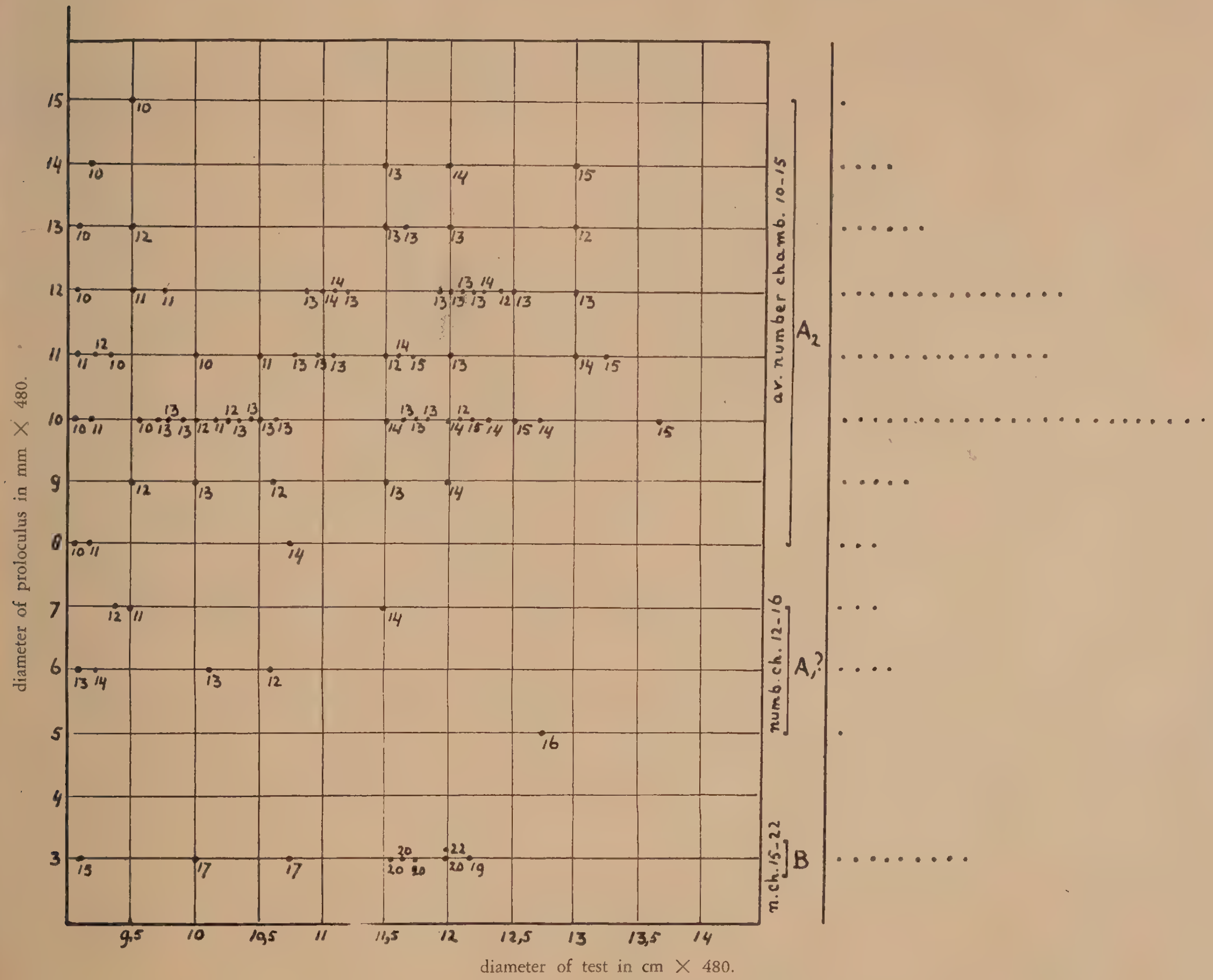


Fig. 322. *Asterigerinata mamilla.* Diagram showing relation between size of proloculus and diameter of test. The figures indicate the total number of chambers.

All these bionomic data point to real trimorphism in this species.

The importance of this species, however, was found in other characteristics. The dorsal side shows two kinds of pores, very fine ones with a diameter of less than 0,5 μ, and coarse ones which

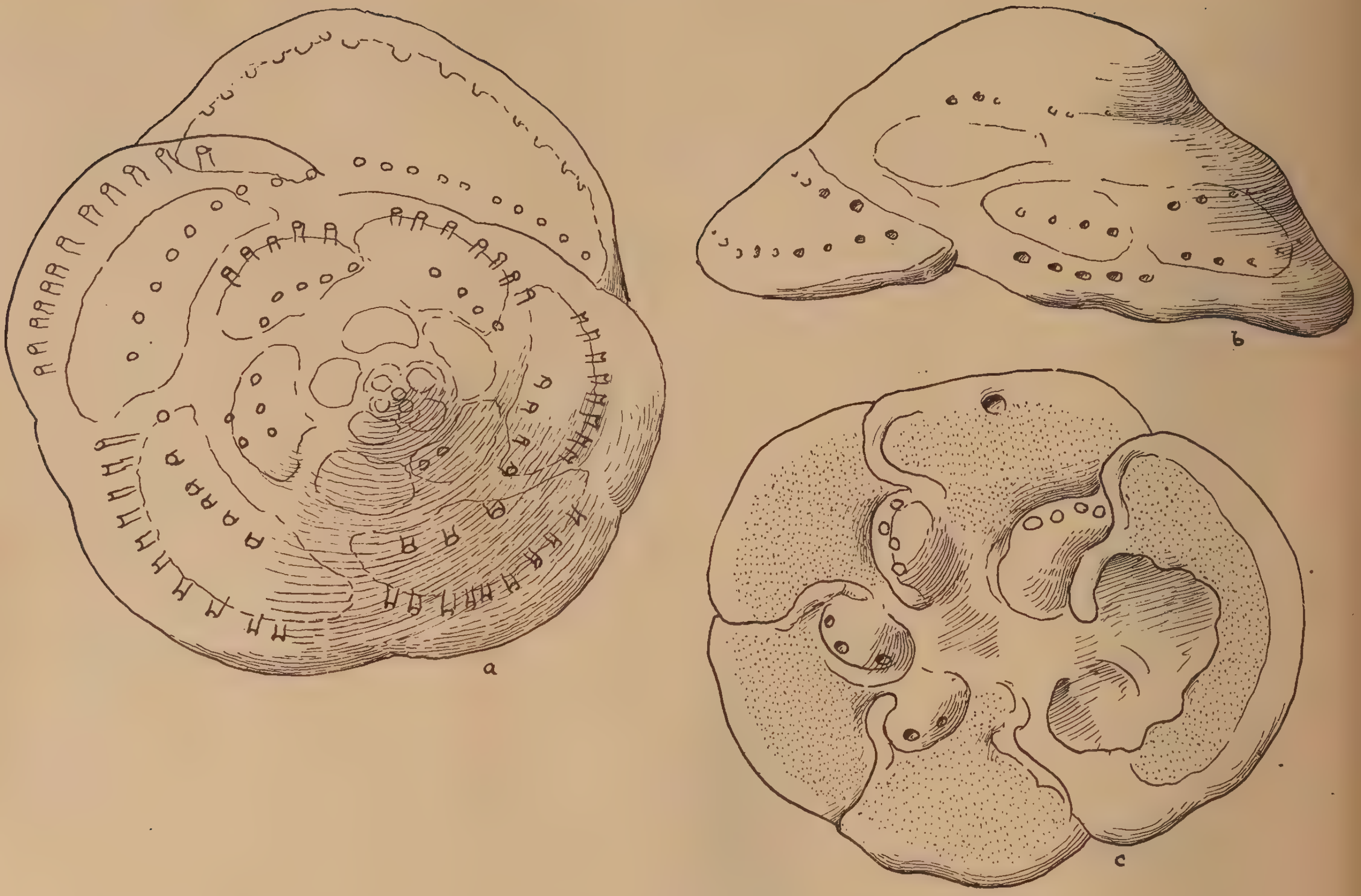


Fig. 323. *Asterigerinata mamilla.* Microspheric specimens from Bay of Napels. a, dorsal side; b, sideview of other specimen; c, ventral side of b, showing absorbed ventral chamberwall of last formed chamber, and the supplementary plates. × 360.

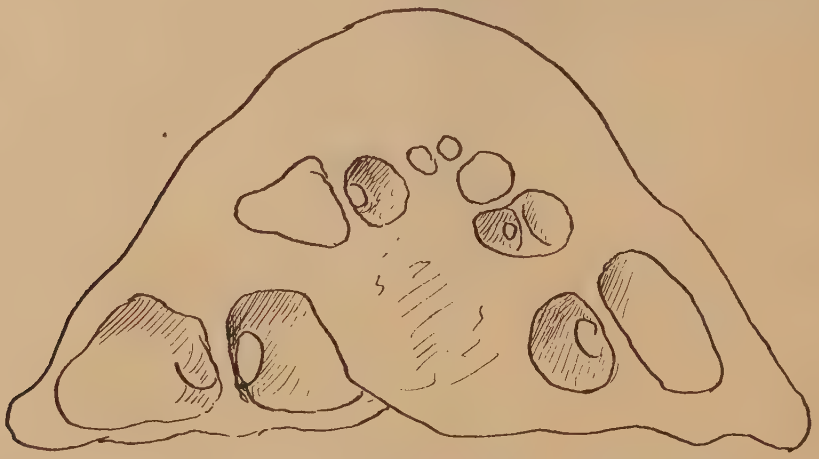


Fig. 324. *Asterigerinata mamilla.* Longitudinal section through microspheric specimen, showing toothplates in chambers and very largely thickened wall at initial part; × 480.

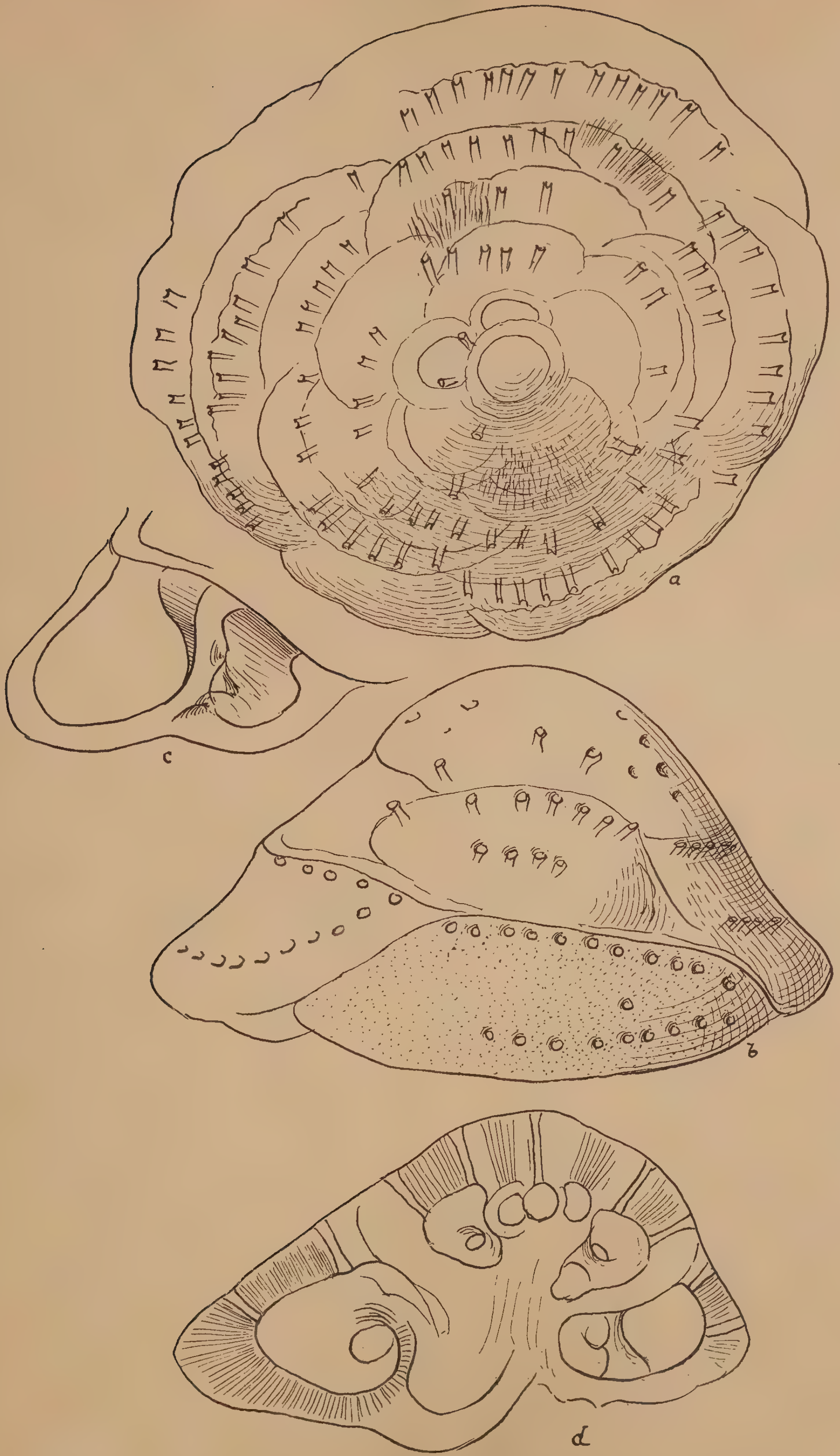


Fig. 325. *Asterigerinata mamilla.* a, dorsal side A2-specimen; b, same specimen from aside; c, ventral chamber with toothplate, section; d, total transverse section through A1-specimen, showing small and coarse pores, and the thickened dorsal wall, the toothplates and the septal foramina. All figs. × 410.

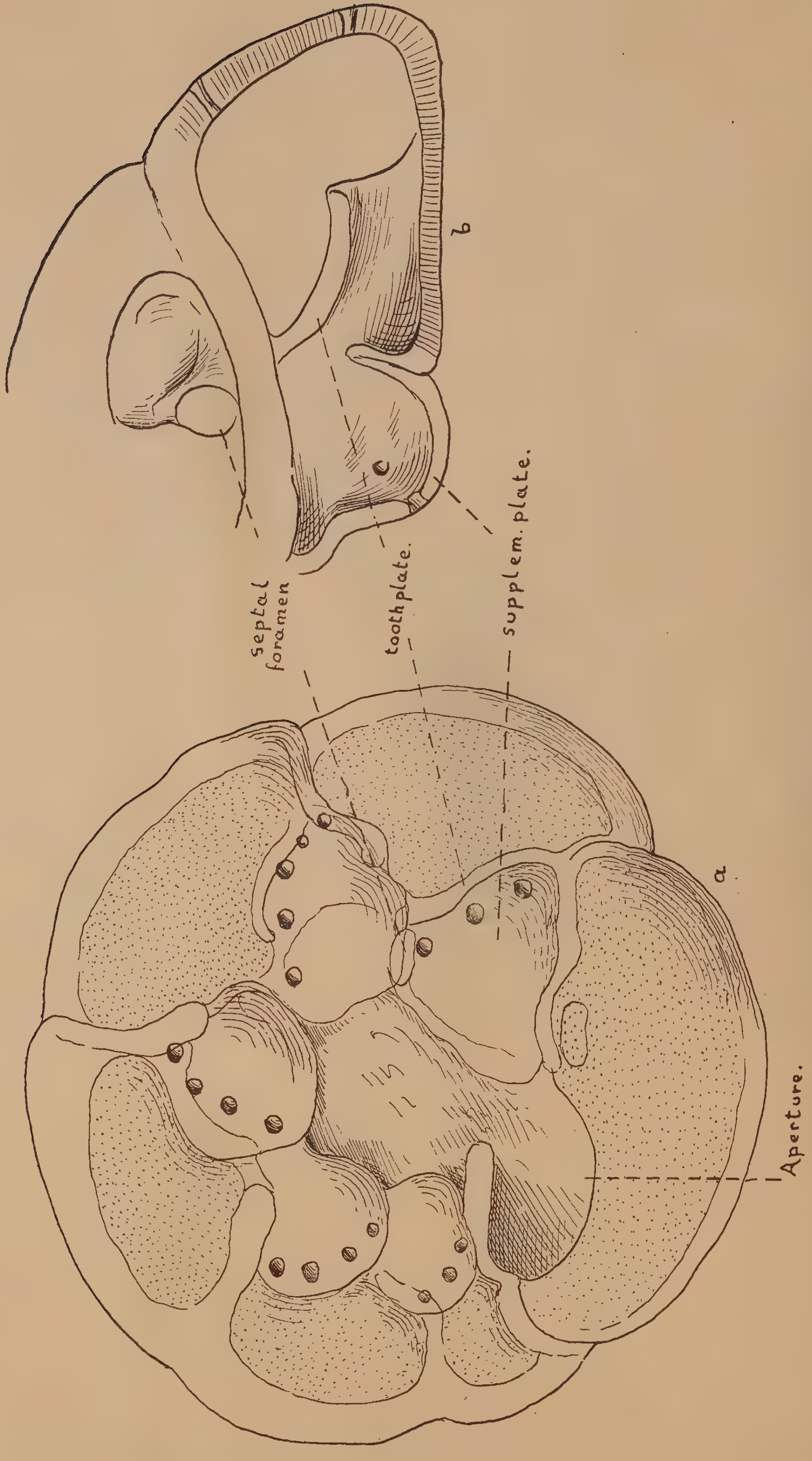

b
septal foramen
toothplate.
supplem. plate.
a
Aperture.

Fig. 326. *Asterigerinata mamilla.* a, individual from the English coast, ventral side, A1-form. The ventral walls of the chambers show their fine pores, the supplementary plates of the toothplates with their coarse openings; b, longitudinal section of ventral chamber showing toothplate, supplementary plate and septal foramen in former chamber. a × 430; b × 560.

are mentioned in the descriptions of the authors. These coarse pores are found in later chambers in two rows, the one at the proximal, the other along the distal suture of the test. As the testwall is a very thick one, though quite hyaline, these pores resemble tubes which, however, do not reach the outer margin of the test, this margin showing only the fine pores. The two rows of pores meet at the distal end of the chamber.

At the ventral side of the test original chamberwalls show only the very fine pores. The last-formed chamber has a large, arched aperture, the proximal border of which is formed by a typical toothplate which is totally identical with that, found in *Discobolivina,* with its pillar-like free folded part and its wing-shaped attached one, running toward the distal septal wall and aperture of the former chamber. When the next chamber is added, the toothplate forms an outgrowth of its ventral part, may be the lacking free folded part, which forms a horizontal and somewhat waved plate, without fine pores, and at its proximal part deviding the former aperture into two unequal parts, the smaller proximal one forming the septal foramen between the former chamber and the just-formed one, and a larger ventral foramen which, however, is totally covered at the ventral side by this horizontal plate, which runs from the curved ventral border of the former toothplate on to the umbilical chalkmass and smoothly fills the umbilical hollow of the test. In this plate a short row of 3-5 large round openings are spared which enable the protoplasm of the former chambers to connect with the outer world.

These typical ventral plates remind one of those, found in *Lamarckina.* Here too they are formed by the toothplates themselves, and here too they separate the septal foramen from the ventral one. But here they remain open at the umbilical side, and consequently do not form the row of pores.

Genus **Cymbaloporetta**

(Figs. 327-331)

There is some reason, why *Cymbaloporetta* should be distinguished from *Cymbalopora* Hagenow from the Upper-Cretaceous. I studied once again this wonderful species from Maestricht; the first chambers are typically trochoid, as in *Cymbaloporetta*; the later chambers open into the umbilical hollow, as in *Cymbaloporetta.* The pores are coarse, as in *Cymbaloporetta*; but no good figures could be made of the typical lateral foramina of the chambers, as found in *Cymbaloporetta,* and a closer study of the structure of the wall showed me, that this wall is arenaceous; thus the species *Cymbalopora* seems to be related to the *Valvulinidae,* and not to the *Conorbinidae,* as *Cymbaloporetta* is without any doubt.

Cushman made a family of the *Cymbaloporettinae,* as they enclose according to him three or four distinct genera. I cannot say very much of *Halkyardia*; but there is no reason whatever to distinguish the genera *Cymbaloporetta* and *Tetromphalus.* The float chamber of the latter is a reproduction-chamber which cannot be generic characteristic, as the bottom specimens lack this chamber and in this form are totally similar to other species of the genus, except for their specific characters. It is even very doubtful, whether the series of apertures of the chambers of *Cymbaloporella tabellaeformis* is a true generic character; I met with several specimens, in which the earlier chambers showed the typical foramina of *Cymbaloporetta,* gradually changing into the multiple foramina, so that the latter are specific, but not generic. *Cymbaloporetta tabellaeformis* seems to be a form of *Cymbaloporetta bradyi* and not a different genus. All known species of *Cymbaloporetta* are found in at least two forms, though they cannot be distinguished by the size of the proloculus.

As in some other species of the *Conorbidae,* the reproduction seems to be somewhat more primitive in this group, and no real trimorphism is found in some species of the group, as is now known by the investigations of Myers and Le Calvez; *Cymbaloporetta poeyi* (*squamosa*) is known in two forms, a flat one and a more conical one; *Cymbaloporetta* (*Tetromphalus*) *bulloides* too shows conical form; *Cymbaloporetta bradyi* from the Pacific region also shows two forms, a somewhat more conical form, known as *Cymbaloporetta bradyi,* and a flattened form, with even somewhat annularly arranged chambers, known as *Cymbaloporella tabellaeformis.* Since in these three typical different species, which furthermore I will call *Cymbaloporetta squamosa* (d'Orbigny), *Cymbaloporetta bulloides* (d'Orbigny) and *Cymbaloporetta bradyi* (Cushman) two forms can be distinguished, I am sure, that these two forms have something to do with different generations, though I am not able to distinguish them in the same manner, as in normal dimorph species.

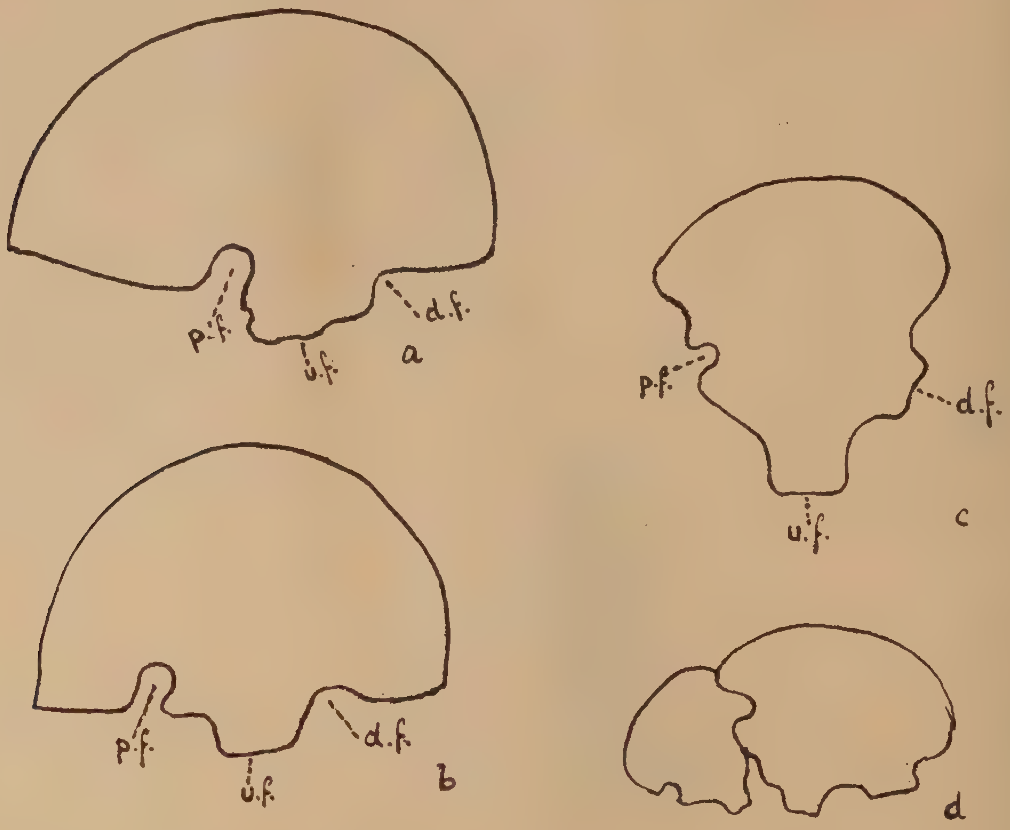


Fig. 327. *Cymbaloporetta.* Schematical figures, showing the development of the foramina of *Cymbaloporetta* out of those, found in *Discopulvinulina.* a. *Discopulvinulina*; b. the protoforamen more marginally placed; c. *Cymbaloporetta;* d. Discopulvinuline and next cymbaloporine chambers in single specimen of *C. bulloides.* p.f.: protoforamen; d.f.: deuteroforamen; u.f.: umbilical foramen.

So I am convinced, that the genera *Cymbaloporella* and *Tetromphalus* cannot be maintained any longer, and that in recent times only the genus *Cymbaloporetta* exists, *Tetromphalus* being only a reproductive stage of a *Cymbaloporetta,* while *Cymbaloporella* is only one of the two forms of *Cymbaloporetta bradyi.*

When studying the external and internal structure of the different species, occurring in the tropical seas, I found, that these species can easily be distinguished by the following characteristics:

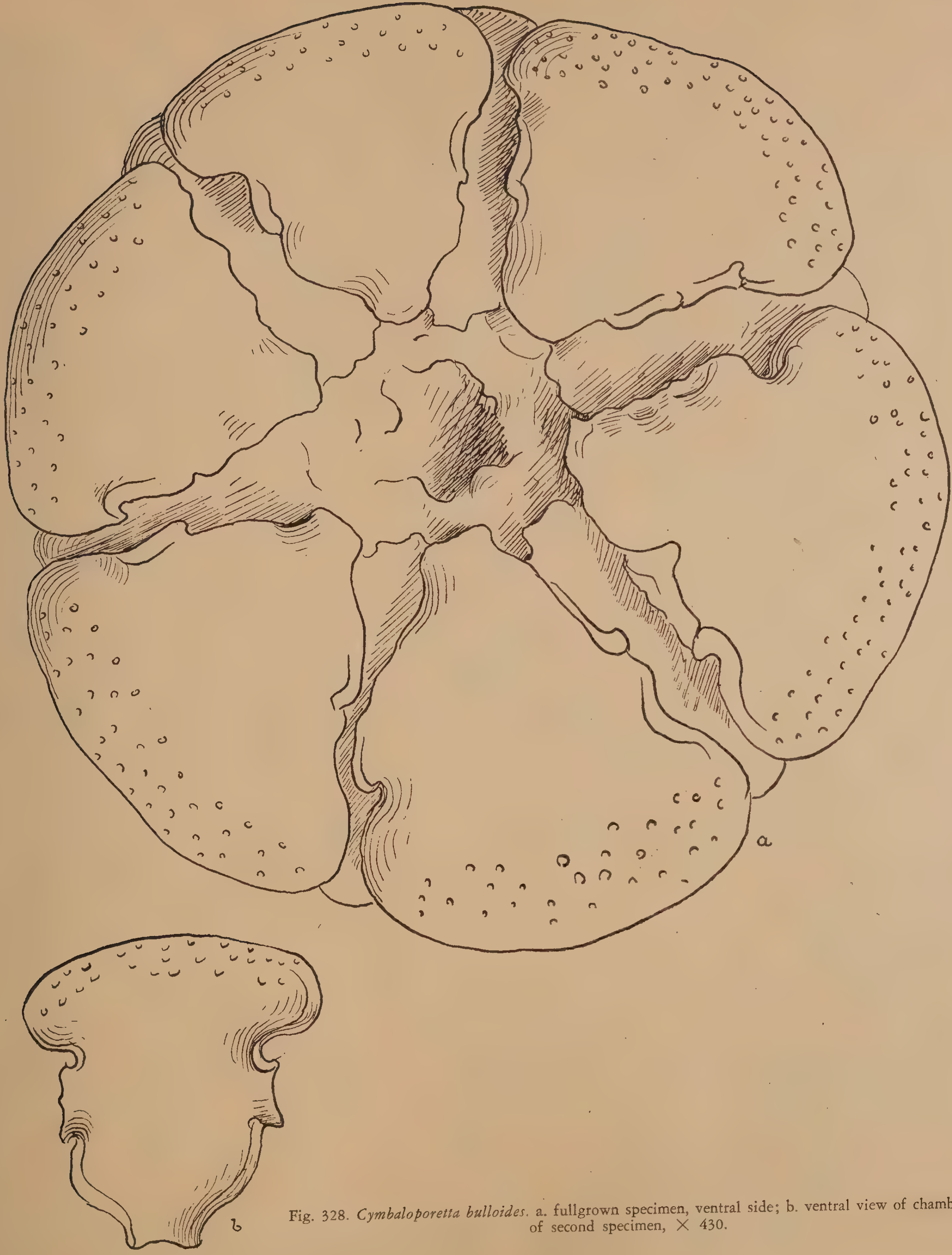


Fig. 328. *Cymbaloporetta bulloides*. a. fullgrown specimen, ventral side; b. ventral view of chamber of second specimen, × 430.

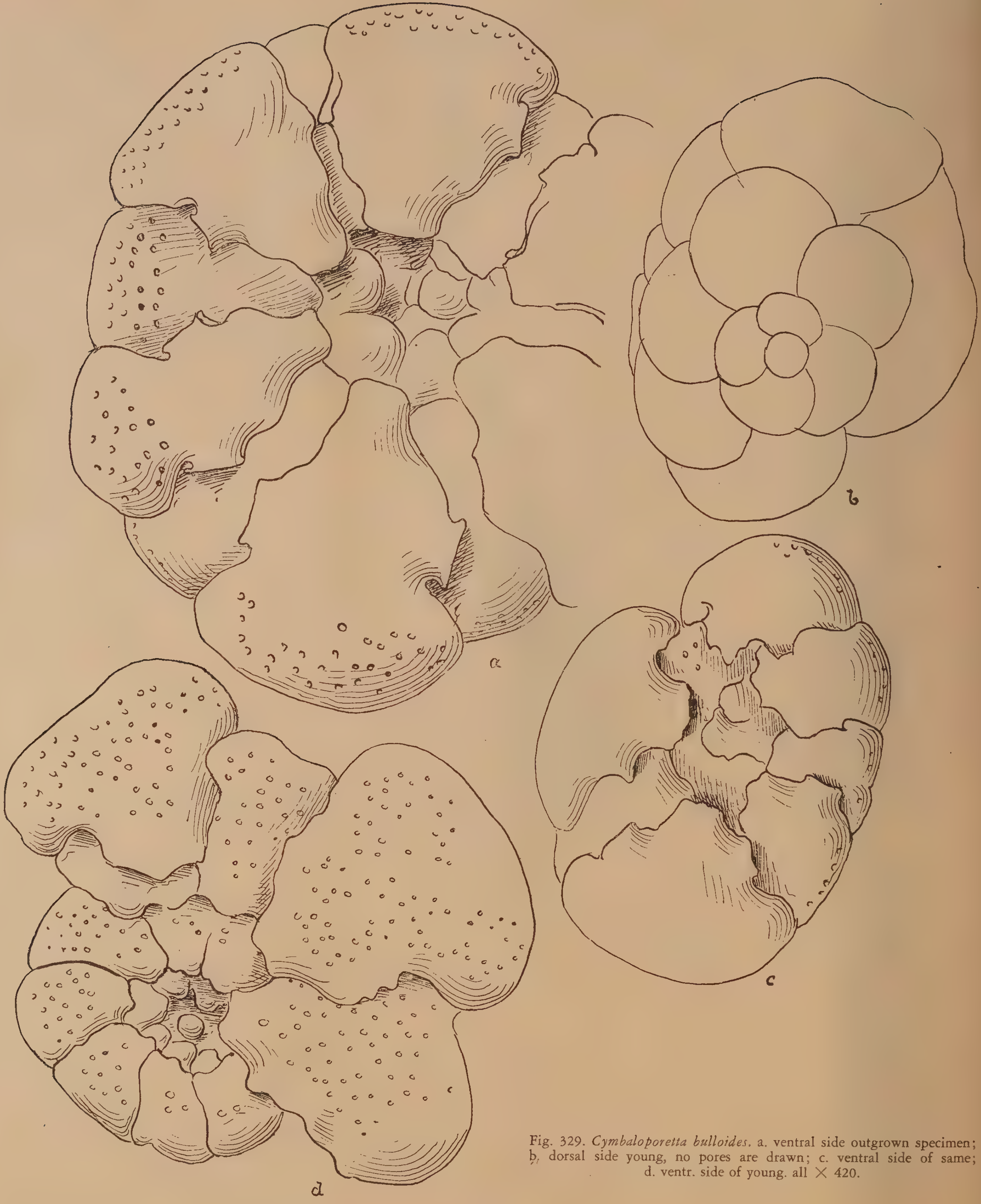


Fig. 329. *Cymbaloporetta bulloides*. a. ventral side outgrown specimen; b, dorsal side young, no pores are drawn; c. ventral side of same; d. ventr. side of young. all × 420.

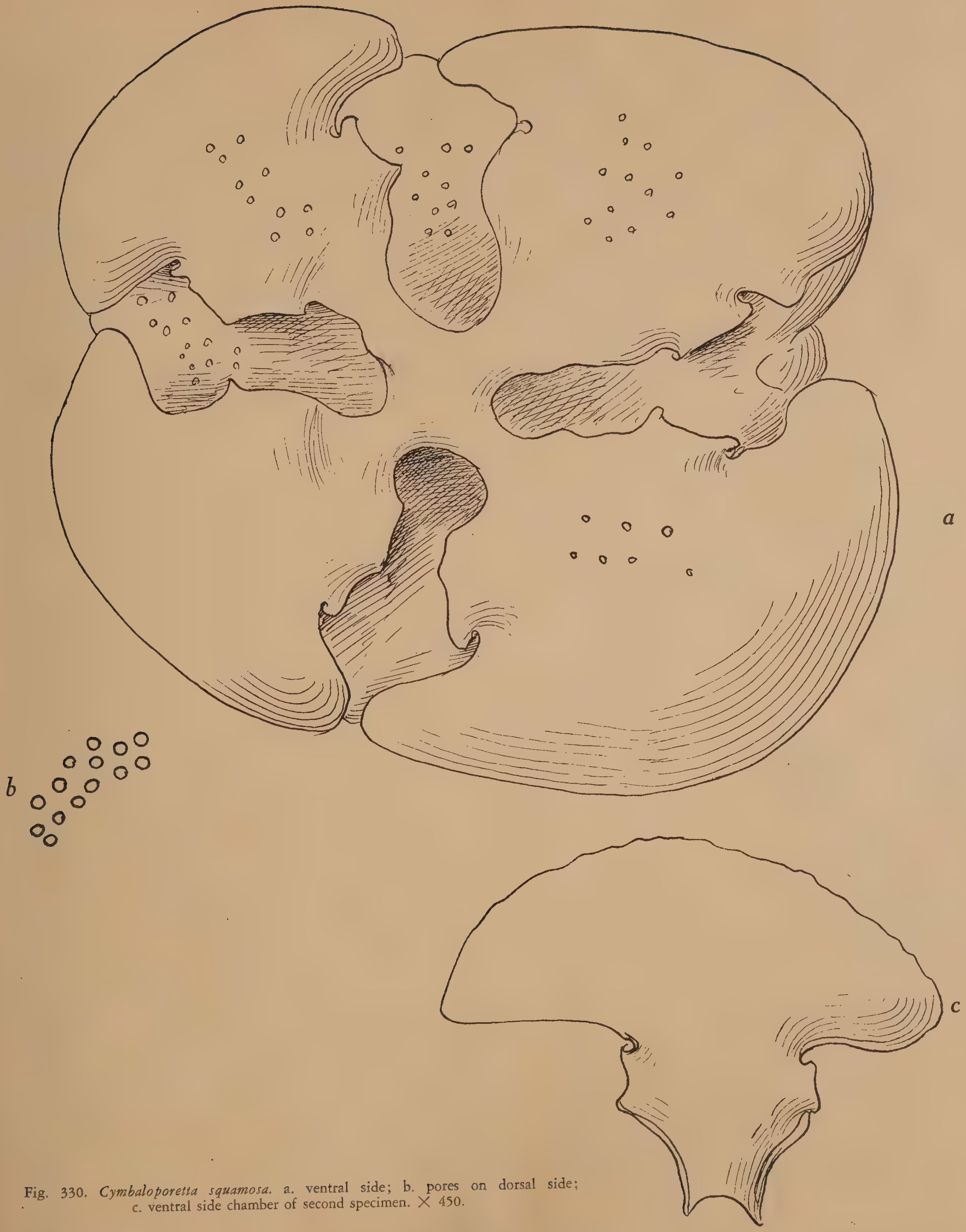


Fig. 330. *Cymbaloporetta squamosa.* a. ventral side; b. pores on dorsal side; c. ventral side chamber of second specimen. × 450.

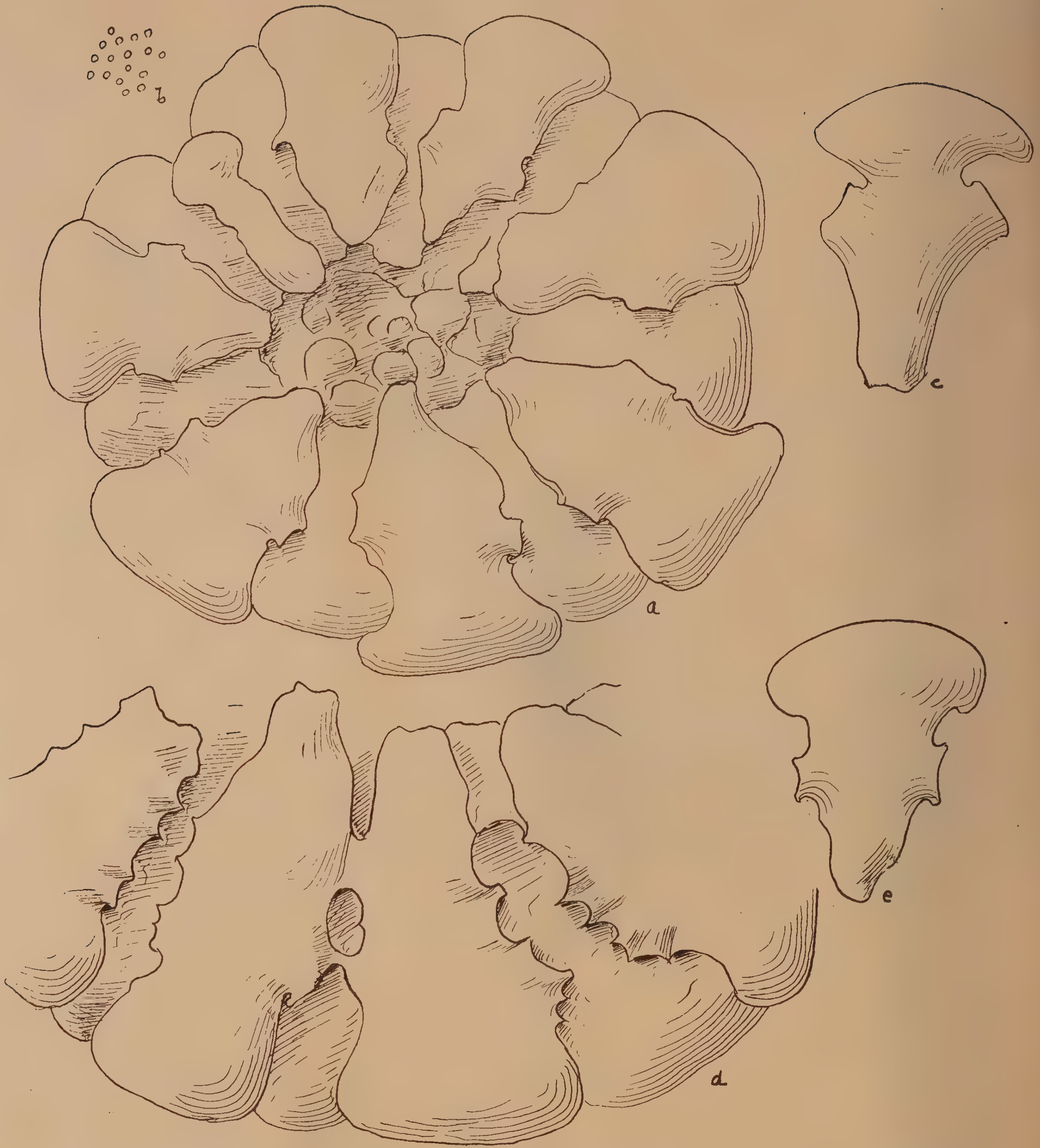


Fig. 331. *Cymbaloporetta bradyi.* a. ventral side of individual with normal endchambers; b. dorsal pores of same; c. ventral chamber of second specimen; × 430; d. part of ventral side of the *Cymbaloporella*-form, showing the multiple foramina; e. chamber of same specimens but from a higher level; × 430.

shape of chambers at ventral side; occurrence of pores on ventral side; umbilical foramina connected by ventral plate covering umbilical region or not; size of dorsal pores; shape of test on transverse section; development of secondary chalk on dorsal initial part; number of chambers on ventral side.

The genus itself shows in all species very typical characters. The test always begins with a trochoid part which shows at its dorsal side rather coarse deuteropores, whereas the ventral side is poreless with hyaline and thickened walls. The septal foramina are rounded and sutural, more or less dorsally placed. The protoforamen always is scarcely visible and often reduced, whereas the toothplate too is reduced up to traces only. All these characteristics point to the genus *Discopulvinulina* from which genus I think that the genus derived.

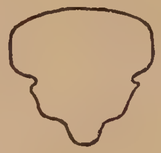
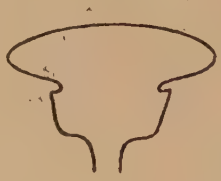
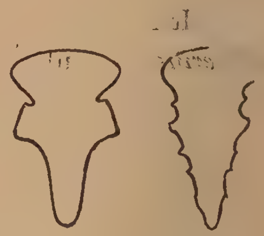
After one or more coils of these typical discorbine chambers, suddenly the chambers alter in shape. The ventral side often remains more or less poreless, but there are found two apertures right and left from the chamber, and a third opening is found directed toward the umbilical hollow.

When comparing the total axial suture on the ventral side of each chamber with that, found in *Discopulv*-species, at once it is clear, that there is not such a high difference between both kinds of chambers. The proximal aperture is formed by the protoforamen; in *Discopulvinulina* and allied genera—when following up the suture, one discovers, that after the protoforamen the suture closes, then opening again to form the deuteroforamen, afterwards closing again, but forming the typical umbilical lip. Here too, after the proximal protoforamen, the suture closes, opening again in the umbilical hollow with the deuteroforamen; then the suture again turns toward the margin (as in all *Discopulvinulina* is the case), forming the lip which, in our genus here, once more opens to form the distal foramen, a second deuteroforamen. Then the suture is once more closed, running toward the margin. I have already mentioned, that the lip seems to have been formed mainly by an outgrowth of the toothplate; it always is poreless, except in some cases (*Asterigerinata*) where it shows large openings, the toothplate pores. In *Cymbaloporetta* those lips melt together and form a hyaline plate over the umbilical region, here too often showing one or more large openings, likewise toothplate pores. In one species, *Cymbaloporetta bulloides,* this basal plate, formed by the melting together of the several lips of the deuteroforamen, forms a very much inflated part of the test in those stages which form the flagellospores or other reproductive cellules, and this "float chamber" thus is formed in its sidewalls by the sidewalls of three or four chambers, showing fine pores, probably protopores, whereas at its basal part is shows the larger toothplate-pores.

Since in this way the real structure of the chambers of the typical *Cymbaloporetta*-type at once has been made clear, it is obvious, that all those genera, beginning, at least in the microspheric form, with a trichoid *Discopulv.* set of chamber, followed by chambers with at least two openings at both sides of the chamber (the *Planorbuline* type, as I have called it in my Siboga I), must have derived from the genus *Cymbaloporetta.* In this way it is clear, that the more flattened types of the genus are the more developed ones, whereas the more primitive form is *C. poeyi* (*squamosa).* From these flattened forms, such as *C. bradyi,* may have derived forms as *Planorbulina,* the only difference being the closing of the umbilical foramen, which is easily intelligible, when in the flattened state the umbilical hollow is lost totally, due to sessile life. From these flattened *Planorbuline* forms the genera derived, in which the chambers have been developed in three directions, such as *Tinopora, Gypsina, Orbitoides,* etc.

The genus *Cymbaloporetta* seems to have developed in the Tertiary.

In my material from the East Indian Archipelago three species of *Cymbaloporetta* are found. They can be distinguished by the following characteristics:

shape ventral chambers.			
	C. bulloides	*C. squamosa*	*C. bradyi*
place ventral pores.	marginal or ventral	mediane	lacking
umbilicus.	open	closed by plate	open
Size dorsal pores × 480	1—2 mm	3—4 mm	2 mm
Size proloculus × 480	5—10 mm	6—8 mm	6—7 mm
transverse section	flat-conical	conical	very flat
Second. chalk on initial part.	none	thick	few.
Number of ventral chambers.	3—6	4—5	8—10

These characters agree with those, found for the West-Indian species *C. bulloides* and *C. squamosa*; but in my East-Indian material *C. bulloides* never showed floating chambers, and *C. squamosa* was of the more rounded type as were the specimens of *C. bulloides*. But the material was only small.

Family *Valvulineridae*

This large family which has been analysed thoroughly by Brotzen in his paper Sver. Geol. Unders., Ser. C., No. 451, 1942, p. 16-35, has been grouped around the genus *Valvulineria*. The typical character of the whole family seems to be the septal foramen which is continued in the umbilical opening. This is a very peculiar character, as in the genus *Discopulvinulina* there exists also a septal foramen, situated as in *Valvulineria* and *Gavelinella*, together with an umbilical opening, the latter covered underneath by a poreless plate, as in *Gavelinella* and its allies, but here the always reduced toothplate is separating both openings. In the genus *Gavelinopsis* which I created, the toothplate is still more reduced, and in *Gavelinella* it is totally absent, whereas both openings are connecting.

The discovery of the intermediate genus *Gavelinopsis* shows, that the family of the *Valvulineridae* has developed from *Discopulvinulina*, or must be closely allied to *Discopulvinulina*, which has already developed in the Cretaceous.

Brotzen enclosed in this family also species, in which no development of a ventral umbilical opening can be traced, viz. *Gyroidina, Rotaliatina, Eponides*. I am sure, that this is a mistake, as it is quite impossible to construct the aperture of these genera from that, found in *Gavelinella* or *Valvulineria*.

The genus *Streblus,* likewise added by Brotzen to this family, cannot belong to it, as it shows a very well developed protoforamen, giving rise to the umbilical canalsystem, found too in real *Rotalia.*

It is not possible that the group, now known as the *Cibicidae,* has developed from real *Valvulinerine* forefathers, as a ventral development of an opening is not yet shown in this group. Moreover most species of the *Cibicidae* show deuteropores, even in ancient types, whereas the typical *Valvulineridae* show protopores. Typical *Gavelinella* and *Gyroidinoides* show no pores at the dorsal side; in the *Cibicidae* on the contrary the deuteropores often are restricted to the dorsal side, whereas the ventral sides often show no pores at all.

Very typical genera, allied to the *Valvulineridae,* are the *Globigerinidae.* They show in their primitive forms always a typical development of a septal foramen, now always laying stress on the ventral part of it, and in many species covered by a distinct poreless lip. They may be regarded as pelagic *Valvulineridae.* But the genus *Candeina* does not belong to this group, with its very fine pores, its development of a reduced toothplate in the initial chambers, and the development of secondary openings along the sutures; I placed it among the *Cassidulinidae* in the neighbourhood of *Virgulinella.*

The development of the *Cymbaloporettinae* from the genus *Rotalipora,* as suggested by Brotzen, cannot be of great value; the sutural mouthes of *Rotalipora* have obviously developed from the lips, covering the ventral foramen, and cannot be homologized with those, found in *Cymbaloporetta.* On the other hand I could state, that *Cymbaloporetta* shows many characters which point directly towards *Discopulvinulina,* and thus they do not belong to the *Valvulineridae.* The same can be said of *Globotruncana, Globorotalia, Globorotalites, Rotalipora.* These genera are always characterized by a very typical poreless keel around the margin in the test, which keel is always absent in real *Valvulineridae.* Moreover they show very typical characters of the aperture and of the septal foramina, which indicate, that they have some relation to *Discopulvinulina.* In that genus many species also show a hyaline keel at the margin, very much resembling that, found in *Globorotalia.* So I gathered these genera in a new family, the *Marginolamellidae,* which seem to have developed from *Discopulvinuline* forefathers from the Cretaceous. They are descendants of *Discopulvinulina,* as are the *Valvulineridae,* but they developed on a different line, maintaining the hyaline marginal keel, found too in many species of *Discopulvinulina.* To this family I gather also the genus *Cancris.* In this genus the ventral lips covering the umbilical foramina have developed into real plates, but always, as in *Discopulvinulina,* poreless, whereas in *Cancris* the hyaline marginal keel is preserved.

Thus to the family of the *Valvulineridae* I brought only the genera *Valvulineria, Gavelinopsis, Gavelinella* and *Gyroidinoides.*

To the family of the *Marginolamellidae* I bring the genera *Globotruncana, Globorotalia, Globorotalites, Rotalipora* and *Cancris.*

Genus **Gavelinopsis** nov. gen.

When studying the species, called by Heron-Allen *Discorbis praegeri,* I found several characteristics which point to the genus *Gavelinella* Brotzen. A typical species of *Gavelinella* is *Gavelinella intermedia* from the Cretaceous. This species I could study in many specimens, kindly afforded by the

Geological Survey of the Netherlands. The species shows most of the chambers with an open aperture in the umbilical region, provided with a distinct lip underneath, partly covering the umbilical cavity. In this species a very peculiar character was discovered too, viz. the lack of pores at the dorsal side of the test. This character was also found in *Gyroidinoides nitida,* a closely allied species from the Cretaceous. Both species I shall describe in another paper.

In *Gavelinopsis praegeri* once more several characteristics are found which point to the vicinity of *Gavelinella*: the dorsal side is poreless, the ventral side shows the very fine protopores, usual in *Gavelinella intermedia* and *Gyroidinoides nitida,* whereas the chambers of the last-formed whorl likewise open into the umbilical region, showing a distinct hyaline covering lip underneath, as in *Gavelinella* and in *Gyroidinoides.* On the other hand the ventral side shows rests of a typical protoforamen, as is found in my new genus *Discopulvinulina.* The fine protopores undoubtedly show the primitive state of the species. But in the centre of the umbilical cavity a hyaline chalk-knob has closed the openings of the initial chambers, thus giving the species a more developed aspect in regard to *Gavelinella.* So I was obliged to create a new genus for this species, as its ancient characters point to *Discopulvinulina* as well as to *Gavelinella,* thus showing a possible missing link between the two groups. I believe it for certain, that the family of the *Valvulineridae* has developed from some ancient Conorbine forefather, loosing its protoforamen, but maintaining its ventral lip underneath the umbilical deuteroforamen. *Gavelinopsis* probably shows the first development of the typical characteristics of the *Valvulineridae.*

Characters of the genus *Gavelinopsis*:

Test more or less conical, convex at dorsal and ventral sides.

Dorsal side without pores or showing them only in the later chambers. The difference between ventral and dorsal sides may be accentuated by a developed keel at the margin. At the ventral side the protoforamen is more or less reduced, but always visible, whereas the umbilically opening deuteroforamen shows a distinct poreless lip, covering part of the umbilicus. Older chambers have the umbilical opening closed by secondary chalk in the umbilicus. Walls always very hyaline, with fine protopores, especially at the ventral side.

The type of the genus is *Gavelinopsis praegeri* (Heron-Allen et Earland).

Gavelinopsis praegeri (Heron-Allen and Earland)
(Figs. 332-334)

I believe, that many specimens, occurring scattered in many samples of Globigerine-ooze ranging in depths from 320-928 fathoms, must be regarded as belonging to the species, described by Heron-Allen as *Discorbis praegeri.* The doubt as to its belonging to the genus *Discorbis,* was already mentioned by Cushman (Bull. 104, pt. 8, 1931, p. 30-31). It may be also, that the Pacific species is a somewhat different species, but, as the description by Heron-Allen is far from accurate, I have chosen the name *praegeri,* adding now a more detailed description, based on the Pacific specimens.

Test small and thin, composed in the microspheric form of 3 convolutions, all visible from the dorsal side, in the A_1-form (the commonest one) by 2½ convolutions, in the A_2-form by 1½ convolution. In the last-formed whorl the microspheric form shows 7 chambers, the A_1-form 5, the A_2-form 6 chambers. The dorsal side is slightly convex, with a higher part in the centre, built up by

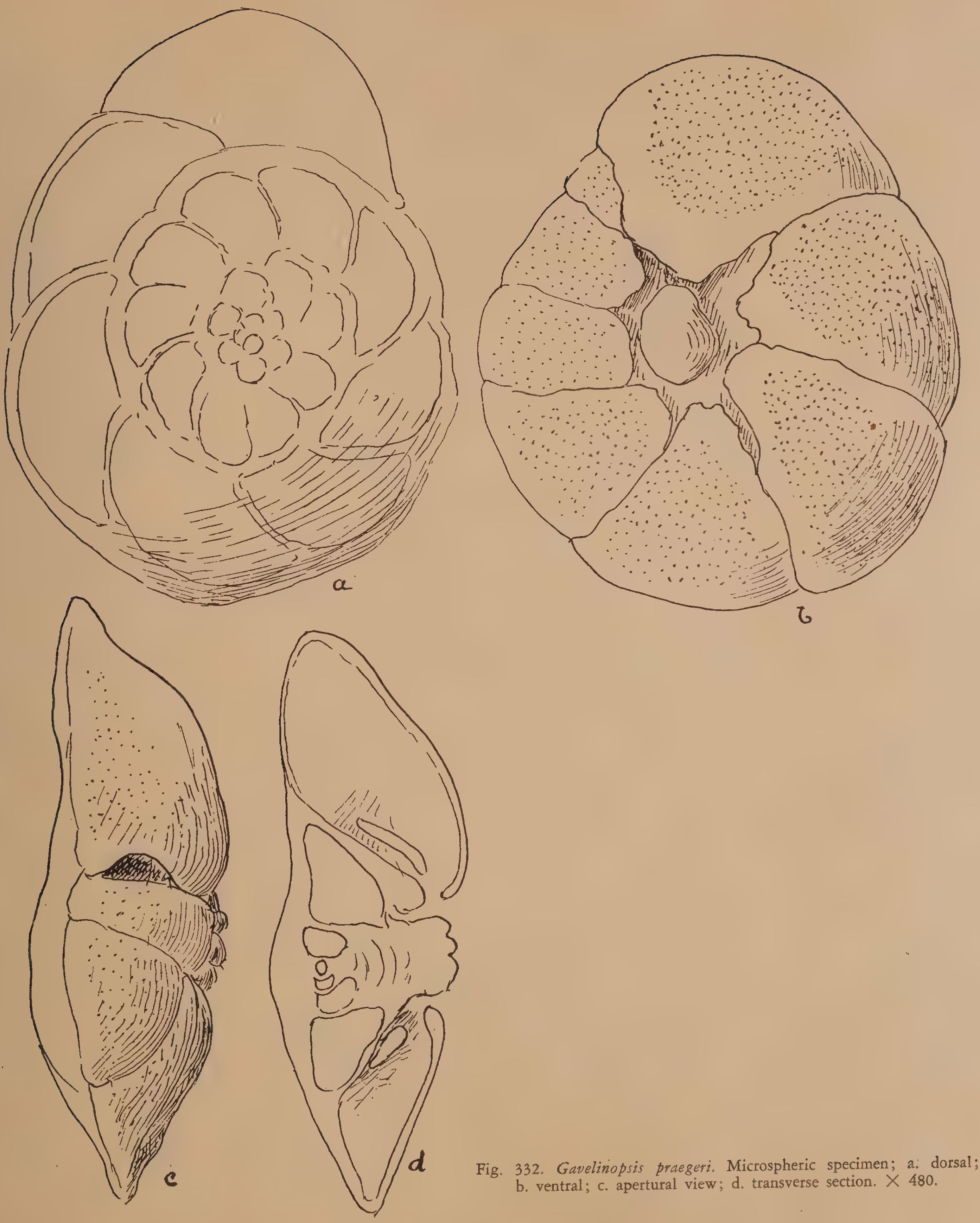


Fig. 332. *Gavelinopsis praegeri.* Microspheric specimen; a. dorsal; b. ventral; c. apertural view; d. transverse section. × 480.

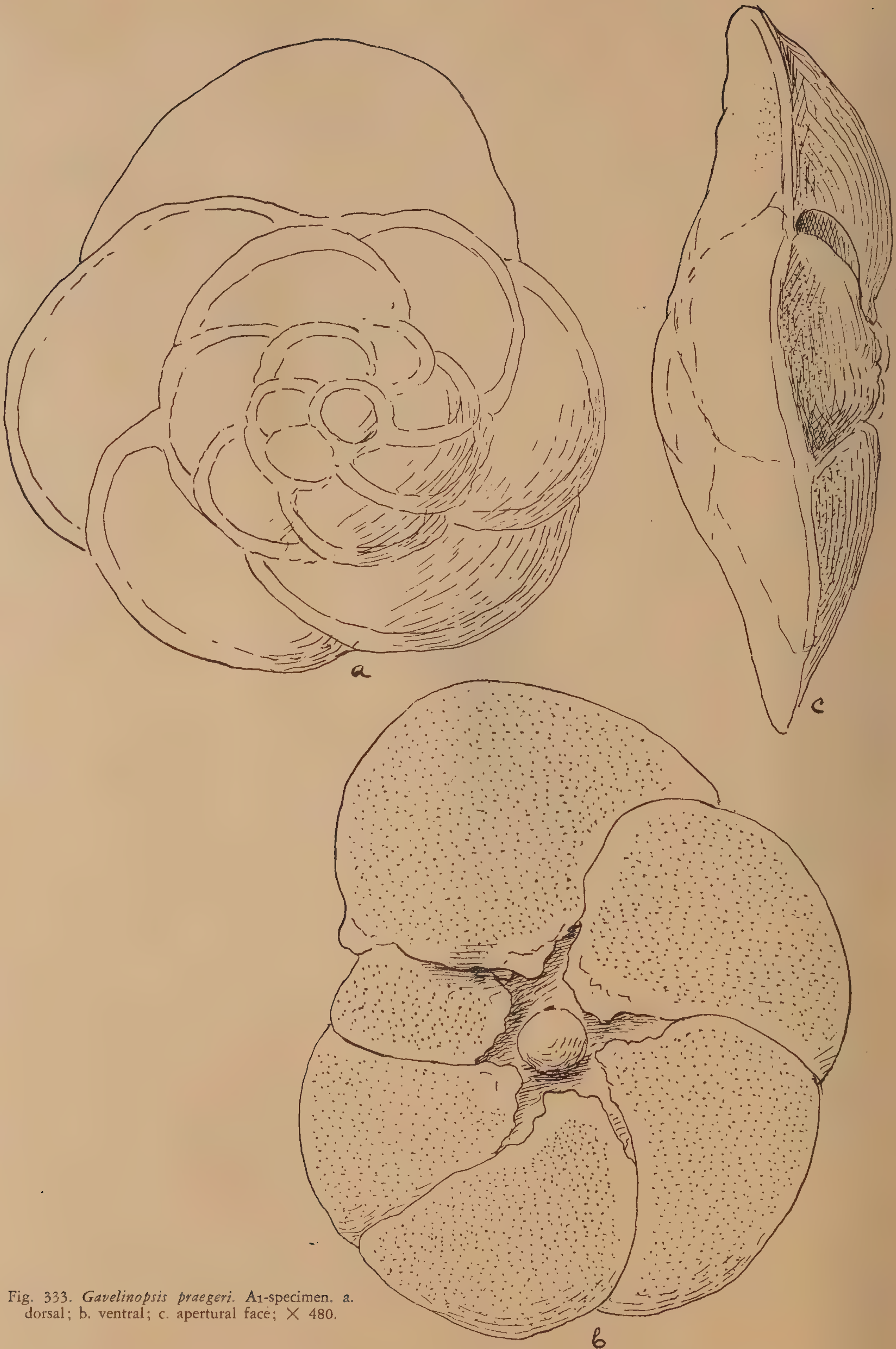


Fig. 333. *Gavelinopsis praegeri.* A1-specimen. a. dorsal; b. ventral; c. apertural face; × 480.

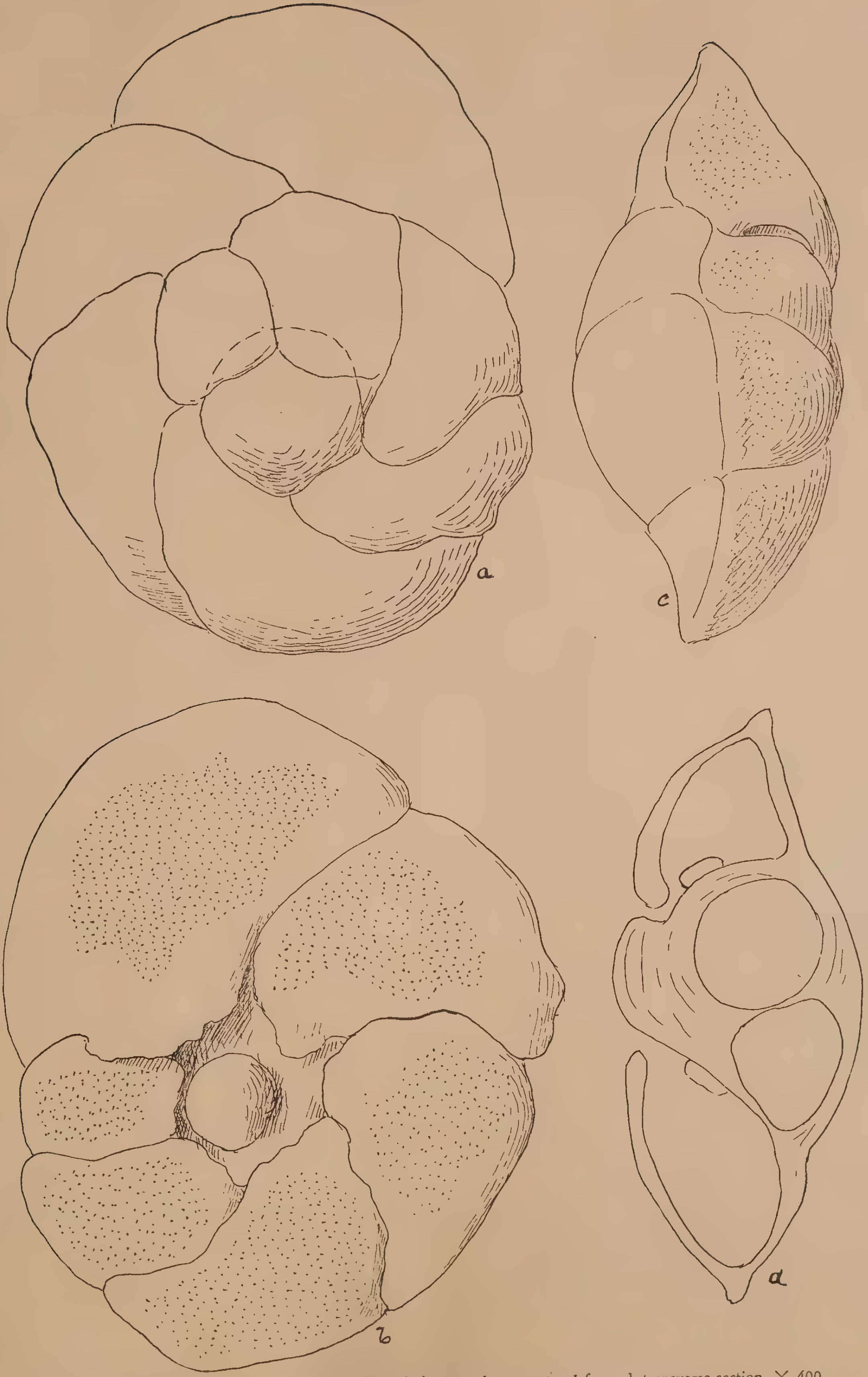


Fig. 334. *Gavelinopsis praegeri*. A2-specimen. a. dorsal; b. ventral; c. apertural face; d. transverse section. × 400.

thickening layers of hyaline chalk; spiral suture of the last formed coil slightly depressed. At the ventral side the chambers of the last formed coil are somewhat inflated, and thus the ventral side is more or less convex too, especially in the microspheric generation. The margin always is distinctly keeled, with a hyaline keel, but not a pronounced one. The dorsal sutures of the chambers are curving backward, at an angle with the margin of about 50°, thus giving rise to chambers which are much broader than high, as is the case in many *Conorbis* species.

At the dorsal side no pores are found, only very fine ones may be formed, hardly distinguishable with high magnification. But at the ventral side there are distinct, fine pores, but for the most central part of each chamberwall which is poreless. A large umbilicus is left free at the ventral side, and the central parts of the lamellum, covering the aperture, protrudes from each chamber into this umbilicus, as is the case in *Gavelinella.* In *Gavelinella* the central part of the umbilicus in most cases is hollow, though in several species the ventral wall of the first coils may be thickened. In our species this thickening has formed a distinct chalkknob, free from the ventral lobes of the apertural lips, and very typical. The aperture is a slit, covered by a ventral lip which in some cases may be irregularly formed and is running from under the margin up to the very umbilicus. But in later chambers this ventral foramen is closed so that only a slit, running at the ventral part along the suture, forms the septal foramen. This is also the case in many other *Gavelinella,* so this is no typical difference between our species and other species of *Gavelinella.* But here this phenomenon is even found in the chamber, former to the last formed one. In fossil *Gavelinella* (Cretaceous) this closing of the umbilical part of the aperture is found only in the first-formed coils. This, together with the fact, that an umbilical plug is formed, enables me to create a new genus, *Gavelinopsis.* To this genus I also count a species, found in the West-Indian region, *Gavelinopsis atlantica,* though here the umbilical plug is only slightly indicated.

The most typical characteristics which show that both genera *Gavelinella* and *Gavelinopsis* belong closely together, are the lack of pores on the dorsal side and the fineness of the pores in both primitive *Gavelinella* and *Gavelinellopsis.* In *Gyroidinoides nitida,* a species very closely allied to *Gavelinella,* likewise pores are lacking on the dorsal side.

Heron-Allen and Earland described the species first from the Irish coast. I got, by the kindness of the Geological Survey of the Netherlands, a sample from off Dog's Bay, in which several well preserved specimens of this species were found. They differ from ous species in the ventral side of the chambers, being more flattened and less inflated than in the Pacific form, whereas the margin is less keeled. These characteristics may be of importance, but are not large enough to separate the Pacific form from the Atlantic one. Both forms are geographic varieties, as all other typical characteristics are found in both forms.

Some specimens, especially at St. 2° 26′ S., 99° 35′ E., depth 582 fathoms, bottom temp. 6,6° C., where the species is abundant, showed no trace of an umbilical knob. Yet their inner structure and the place of the pores was the same. They show a slight but distinct furrow at the ventral aperture, like that of typical "*Discorbis*"; this indicates, that they have possibly derived from *Discopulvinulina.* In some fossil species, e.g. in *Gyroidinoides* from the lower Cretaceous, this furrow can be found too. So it may be, that the genera *Gavelinella, Gavelinopsis* and *Gyroidinoides* derived from *Discopulvinulina,* obliterating the toothplate, but preserving the ventral aperture and the ventral lip underneath.

Family *Rotalidae*

This family has already been described in the first part of the Siboga Report (1927, p. 34-52). Our knowledge about its representatives now has separated the genus *Streblus* gathering those forms, in which the canalsystem is not fully developed and in which the ventral sutures form merely open depressions, as described by Brotzen. Moreover the protoforamina in *Streblus* are more or less present and open at the ventral sides, forming the beginning of the umbilical canalsystem. From this genus have developed various other genera, such as *Rotalia,* distinguished by the development of interseptal canals, *Asterorotalia* (not yet distinguished in 1927) with typical elongate plates covering the ventral parts of the sutures, and *Hyalinea,* a flattened *Streblus.* Higher developed genera are *Calcarina, Baculogypsina,* already analysed in Siboga I. The family has developed in the Upper Cretaceous.

The most typical characteristic of the family is found in the development of the canalsystem, which is not found in any of the other families of the *Deuteroforaminata.* It consists mainly of an umbilical system, originating in the protoforamina, to which system an interseptal one may be added in higher forms. This canalsystem often gives rise to the building of spines (*Calcarina, Baculogypsina*) in which canals are running, connected with the umbilical system.

Genus **Streblus**

This genus has been discussed by Brotzen (Sver. Geol. Unders., Ser. C., No. 451, 1942, p. 21) where he says:

"Genotype *Streblus beccarii* (Linné), *Nautilus Beccarii* Linné 1767. Form der Schale ähnlich *Pseudovalvulineria* oder *Eponides.* Mündung interiomarginal septal, umbilical und sutural. Umbilicus ähnlich wie bei *Pseudovalvulineria* vorhanden oder fehlend, mit Nabelknopf oder Nabelscheibe. Umbilicalmünding mit sekundären Austritten in den Kammersuturen, oft ein kompliziertes System bildend."

This rather short description is open to criticism. The outer form of the test in several species is variable, so that its resemblance with *Eponides* cannot be of generic value. Moreover I have found, that the genus *Eponides* shows no ventral foramina. The interiomarginal aperture consists of two apertures, one the protoforamen, the other the deuteroforamen. Only the latter aperture may be described here as interiomarginal. This aperture however is not umbilical. The umbilicus cannot be absent in a genus, in which the protoforamen opens at the ventral side. So it is always present in real *Streblus,* but in the higher forms, *Rotalia,* it may be filled up partly by secondary chalk. In this chalkmass are running the umbilical canals, deriving from the mouthes of the protoforamina and often forming a spiral canal as well. This is however the case in *Rotalia,* not in *Streblus.* In *Streblus* the openings of the protoforamina are found at the surface of the umbilical region, and no real canals are formed yet. Another characteristic distinguishing the genus *Streblus* from the higher organized *Rotalia* is found in the lack of interseptal canals in the former genus. It is not the deuteroforamen which opens into the sutures of the chambers, but the protoforamen. The deuteroforamen forms the septal foramen of older chambers.

So I separate the higher organized forms, such as *Rotalia schroeteriana,* from the more primitive forms which are gathered in the genus *Streblus.* I will point to the fact, that Brotzen has called some primitive Rotalids, as *Rotalites trochidiformis,* which species belongs to the *Conorbis-*

group, also *Rotalia.* I believe, that it will be much more adequate, to call those primitive forms, which are not very well described by Lamarck, *Rotalites,* whereas the highly developed forms with septal canals and an umbilical spiral canalsystem formed by the protoforamina, have to be gathered in the genus *Rotalia.*

Thus the main characteristics of *Streblus* are:

Test trochoidally coiled, beginning with simple proloculus in all generations. All chambers visible dorsally, only those of the last formed whorl ventrally. Sutures depressed, especially the ventral ones. These show in young forms a distinct protoforamen in the form of a distinct sling in the suture, and the interiomarginal sutural deuteroforamen is covered by a ventral lip which often grows partly over the umbilicus. Umbilicus always present, but often filled up with irregular knobs of secondary chalk. The sunken sutures at the ventral side are the beginning of a septal canalsystem which, however, in this genus is not developed. At dorsal and ventral sides fine protopores, which are often lacking at the sutures and always on the lips of the apertures and around the protoforamen. This protoforamen in older chambers is closed by secondary chalk. In some forms the whole test is covered by knobs of secondary chalk. Pillar like toothplates connected with the protoforamen.

Cretaceous-Recent.

The *Streblus beccarii*-group
(Figs. 335-342)

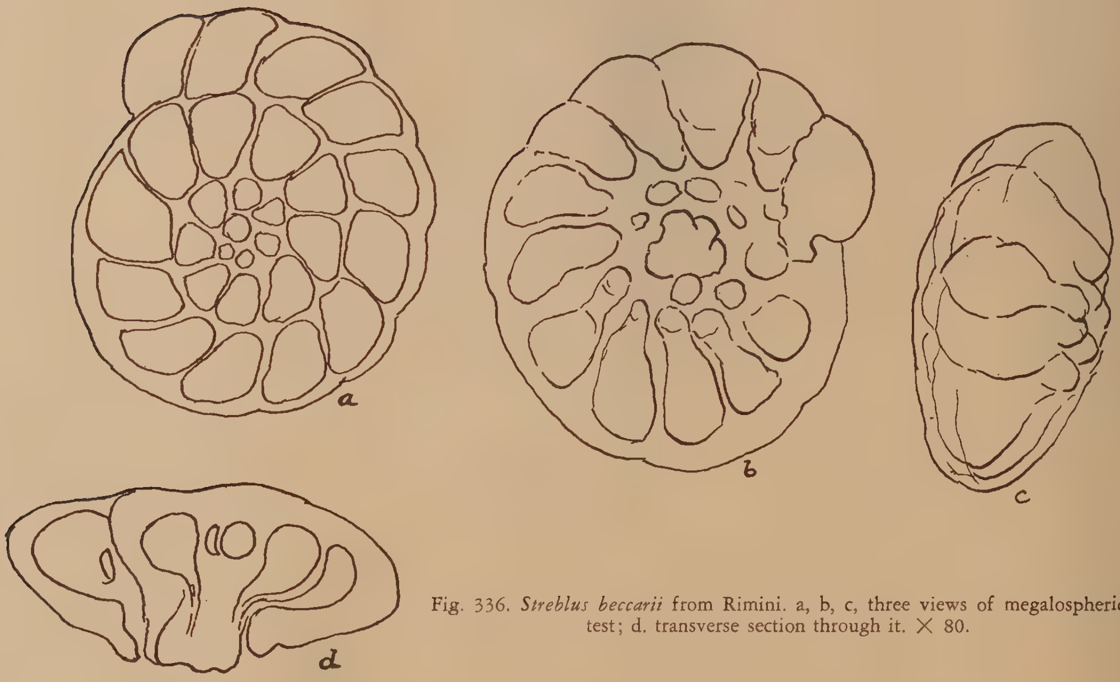


Fig. 336. *Streblus beccarii* from Rimini. a, b, c, three views of megalospheric test; d. transverse section through it. × 80.

Streblus beccarii (Linné), *S. batavus* nov. spec., *S. turgidus* nov. spec.

When studying young and adult specimens of *Streblus beccarii* from the original locality at the coast of Rimini, I found, that this species shows several characteristics which point directly to the

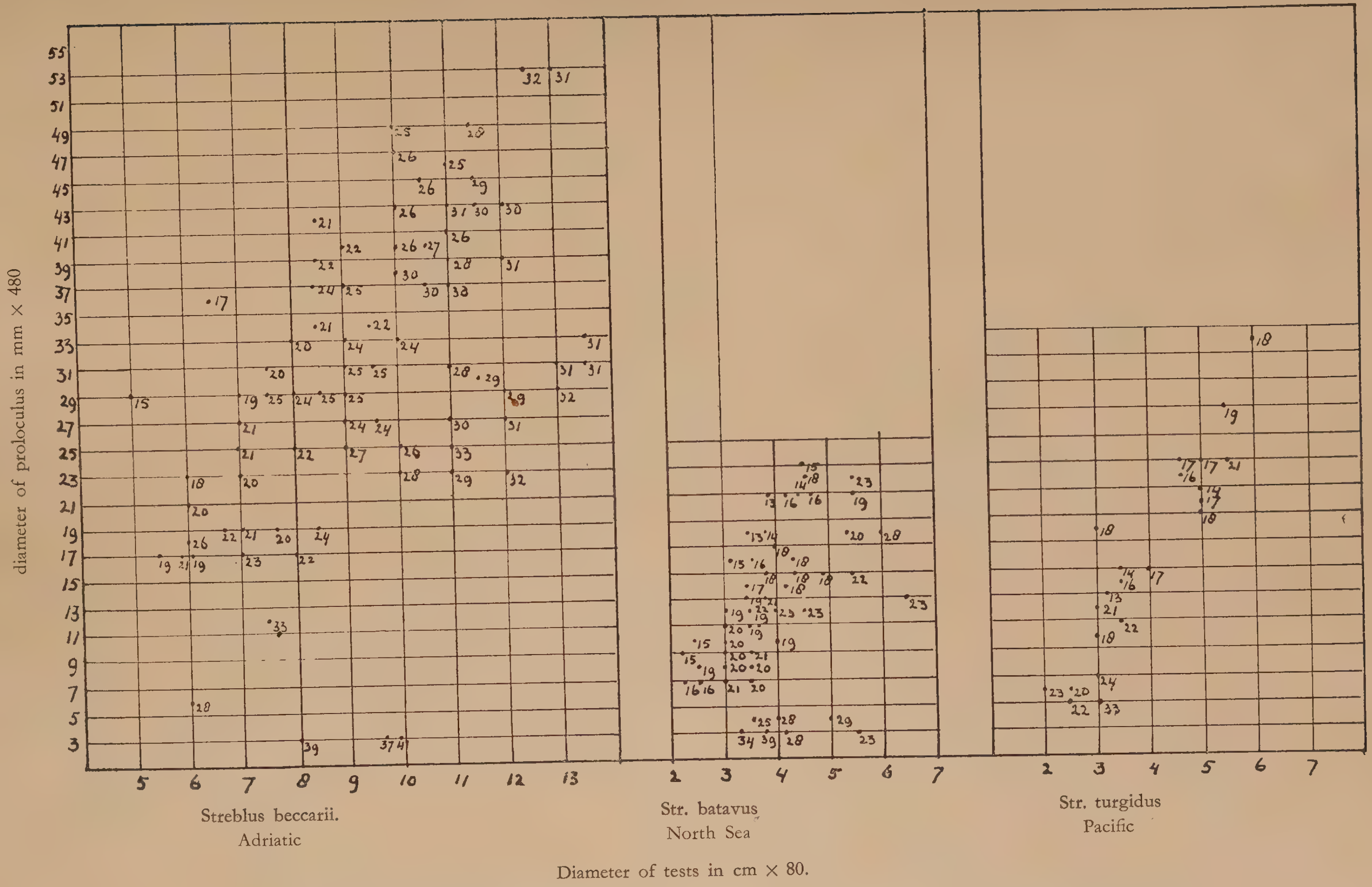


Fig. 335. The *Streblus-beccarii*-group. Diagrams, showing relation between size of proloculus and diameter of test; figures indicate number of chambers. In these diagrams the difference between the three species is clearly shown.

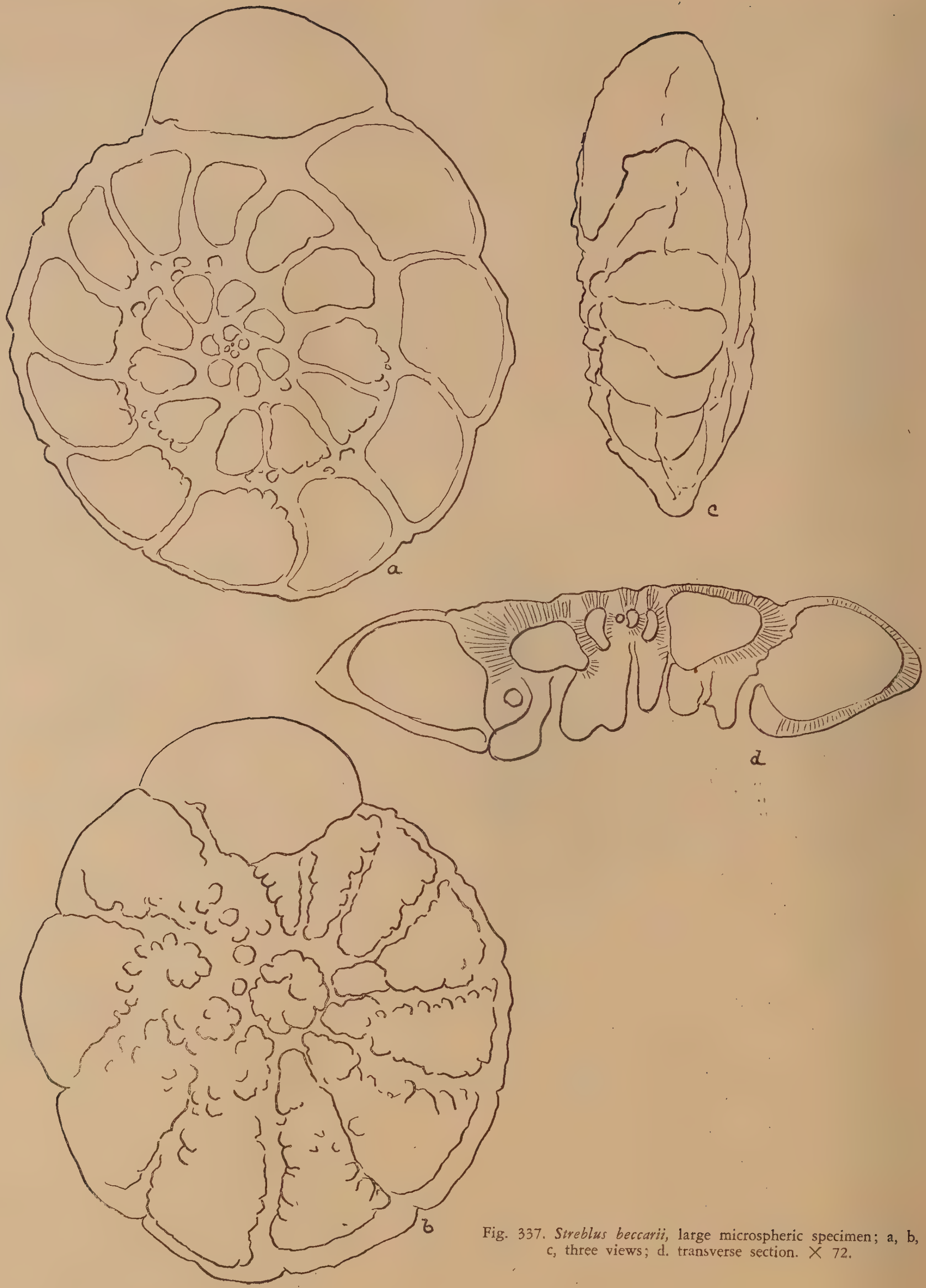


Fig. 337. *Streblus beccarii,* large microspheric specimen; a, b, c, three views; d. transverse section. × 72.

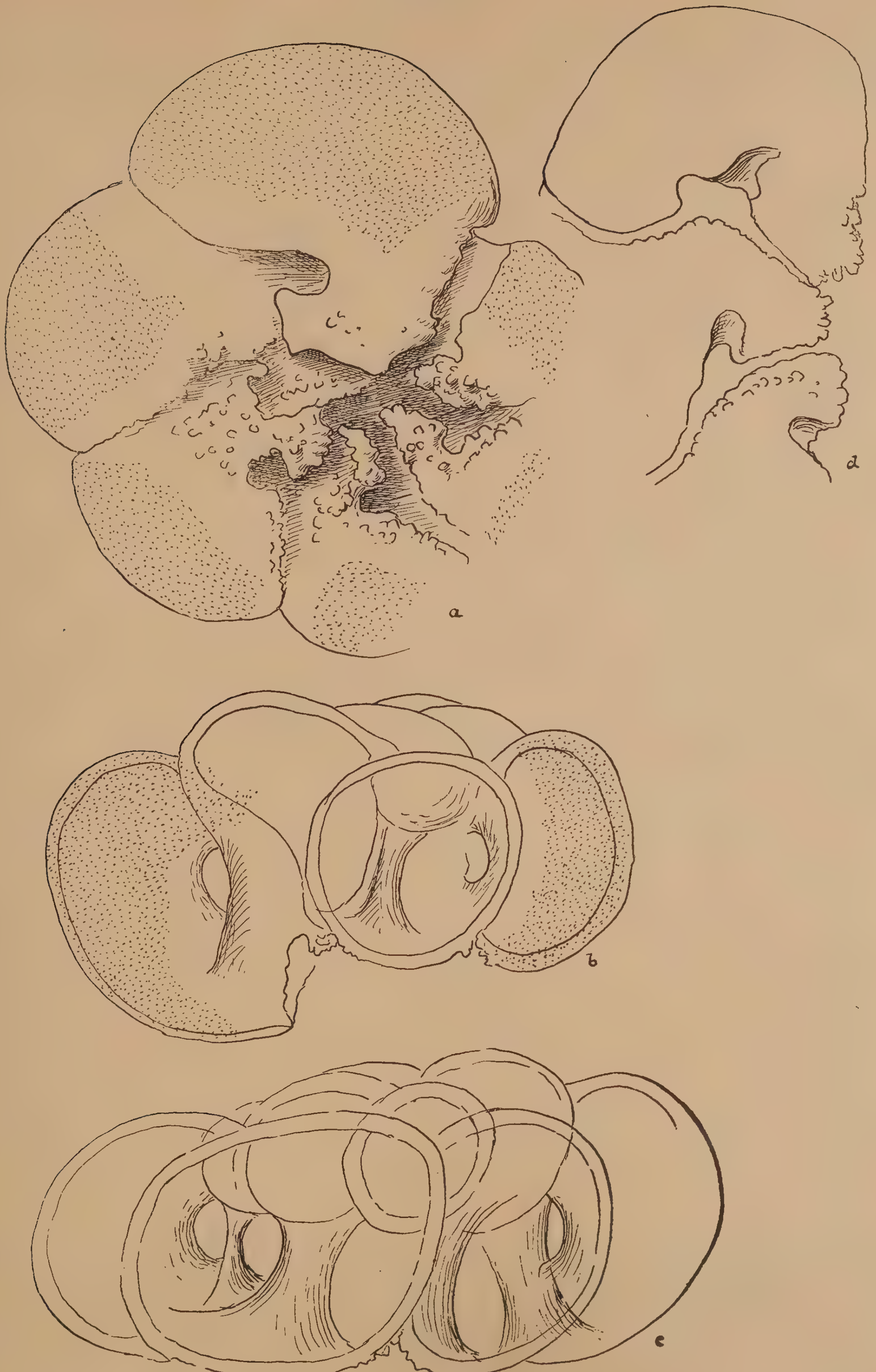


Fig. 338. *Streblus beccarii* from Rimini, young. a. ventral side; b. Apertural side, optical section; c. Antapertural side, optical section; d. optical horizontal section through three last formed chambers, showing toothplate at protoforamen. × 380.

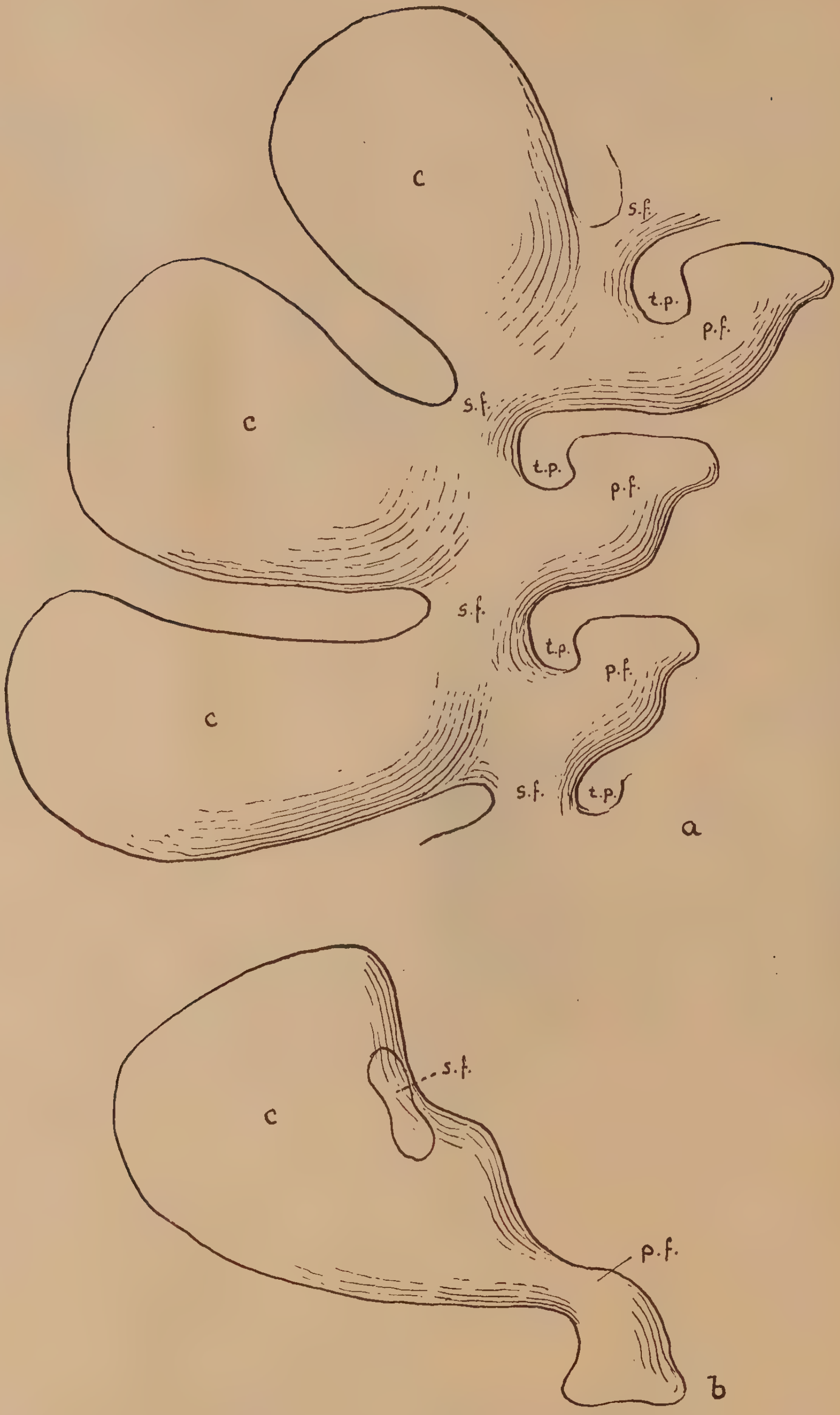

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Fig. 339. *Streblus beccarii* from Rimini. Canadabalsam preparations. a. horizontal section, ground down from dorsal side, showing chambers with "ventral foramen"; b. transverse section through a chamber. × 480; c. chambers; s.f.: septal foramen; p.f.: protoforamen; t.p.: toothplate.

genus *Conorbis.* Young specimens ventrally show the typical protoforamen at the ventral suture, connected with a pillar like toothplate running upward, whereas the deuteroforamen is an opening, distally situated from this protoforamen and covered by a typical lip, somewhat overlapping the umbilical hole. This lip and the region around the protoforamen are lacking the pores, which in all species are fine protopores, as in the genus *Conorbis.* At the rounded margin there is no poreless keel, so that a connection with the *Marginolamellidae* is absent. The production of secondary chalk at the lips and at the borders of the protoforamen lead, in older specimens, to the forming of the typical umbilical canalsystem. I payed special attention to the so called ventral foramen of the cham-

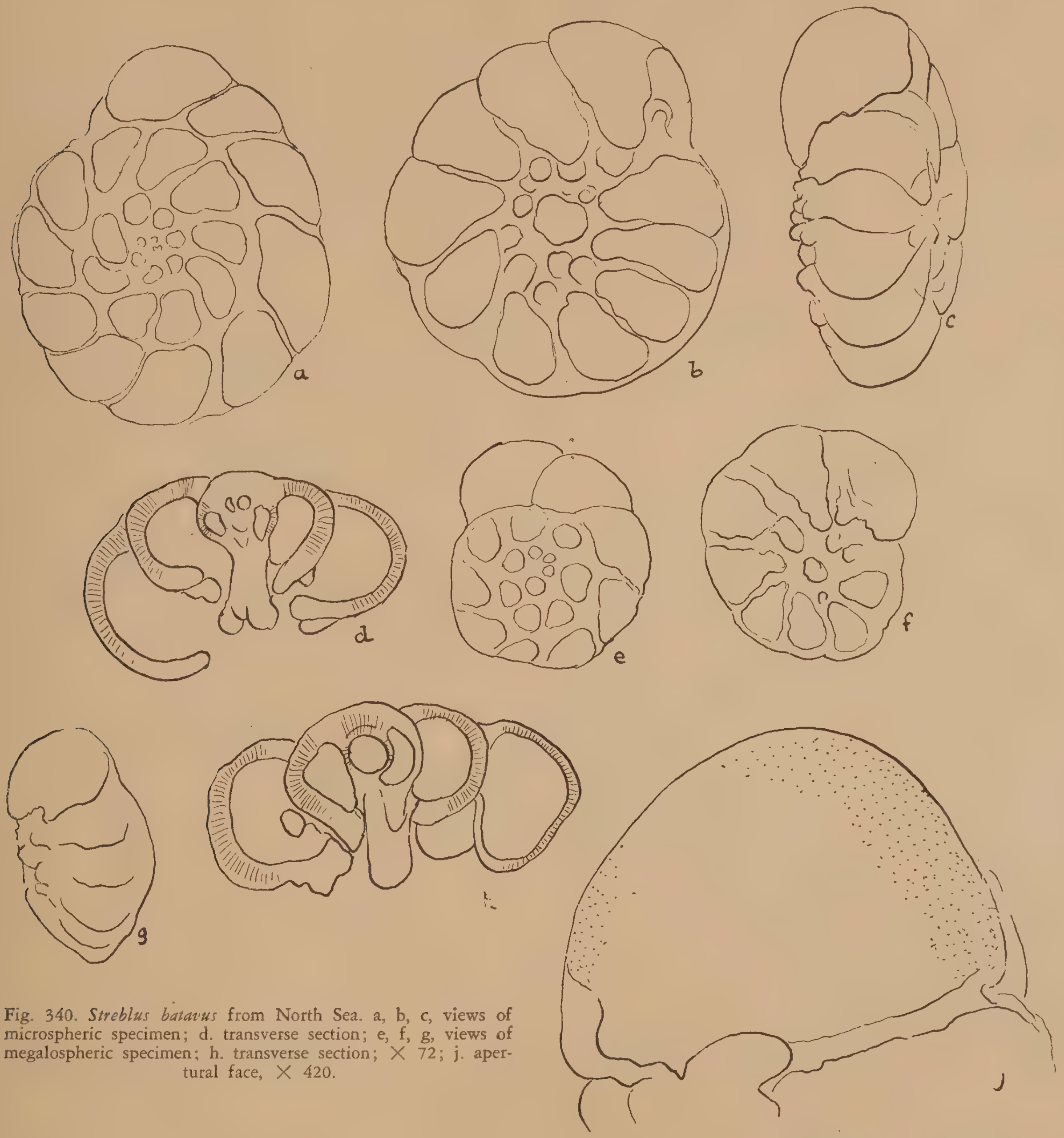

Fig. 340. *Streblus batavus* from North Sea. a, b, c, views of microspheric specimen; d. transverse section; e, f, g, views of megalospheric specimen; h. transverse section; × 72; j. apertural face, × 420.

bers, and I found, that without any doubt this ventral foramen is formed by the protoforamen, as is clearly shown, when horizontal sections are filled up with the Canadabalsam method. In *Streblus* the septal walls are simple, as in *Conorbis,* and consequently there are no true septal canals.

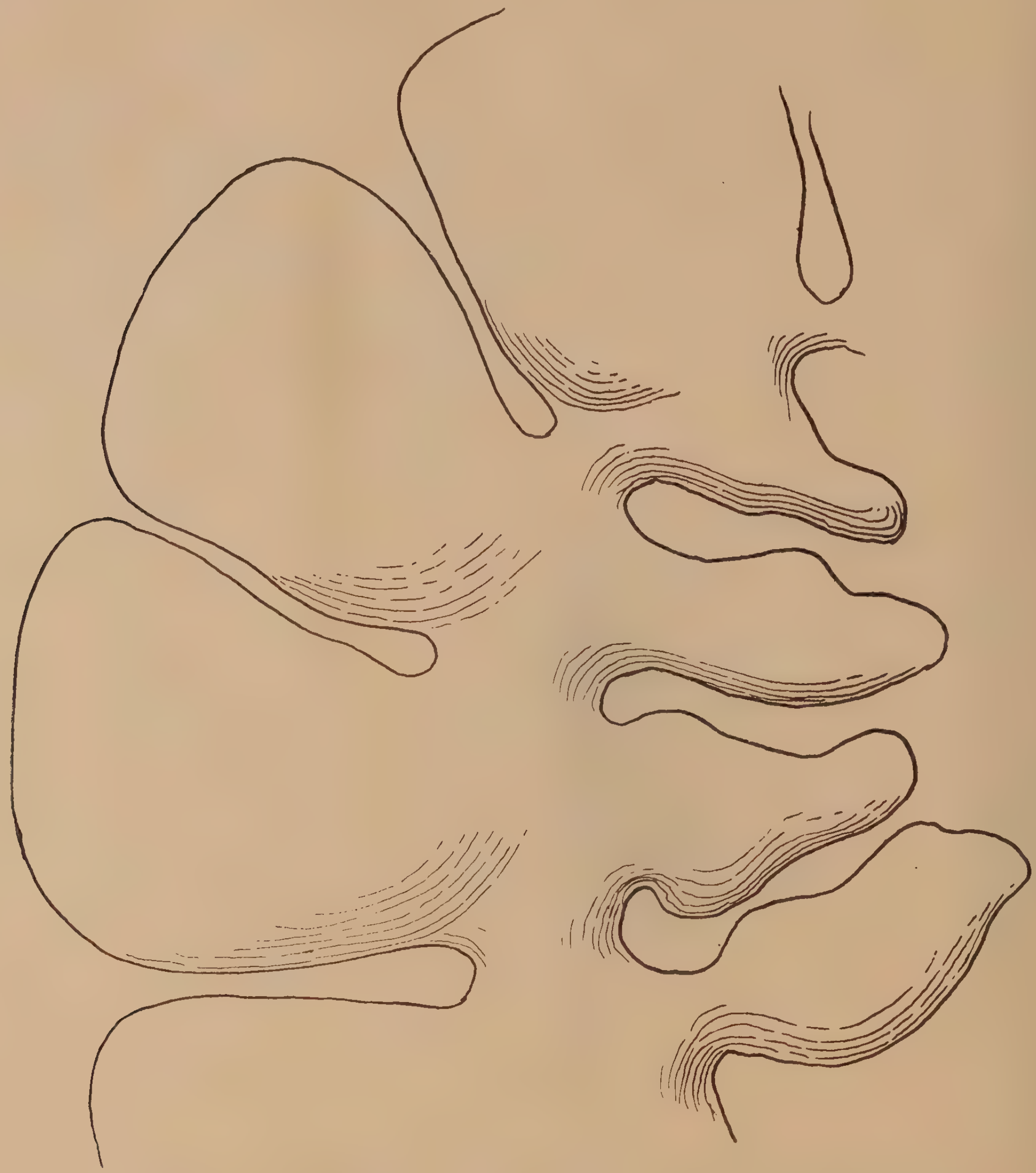

Fig. 341. *Streblus batavus* from the North Sea. Horizontal section of umbilical region of a Canadabalsam preparation. × 480.

All these characteristics, found in *Streblus beccarii* from Rimini (I have to point out, that the species, mentioned in literature as *S. beccarii* from the North Sea is, statistically as well as structurally, a species, different from that, found in Rimini, and has to be called *Streblus batavus* nov. spec.) viz: ventral protoforamen, pillar-like toothplate connected with protoforamen, simple septal walls, ventral lip over deuteroforamen, poreless part bordering protoforamen and lip, fine protopores, no poreless margin, point to the fact, that *Streblus* is very closely allied to *Conorbis.* It is a

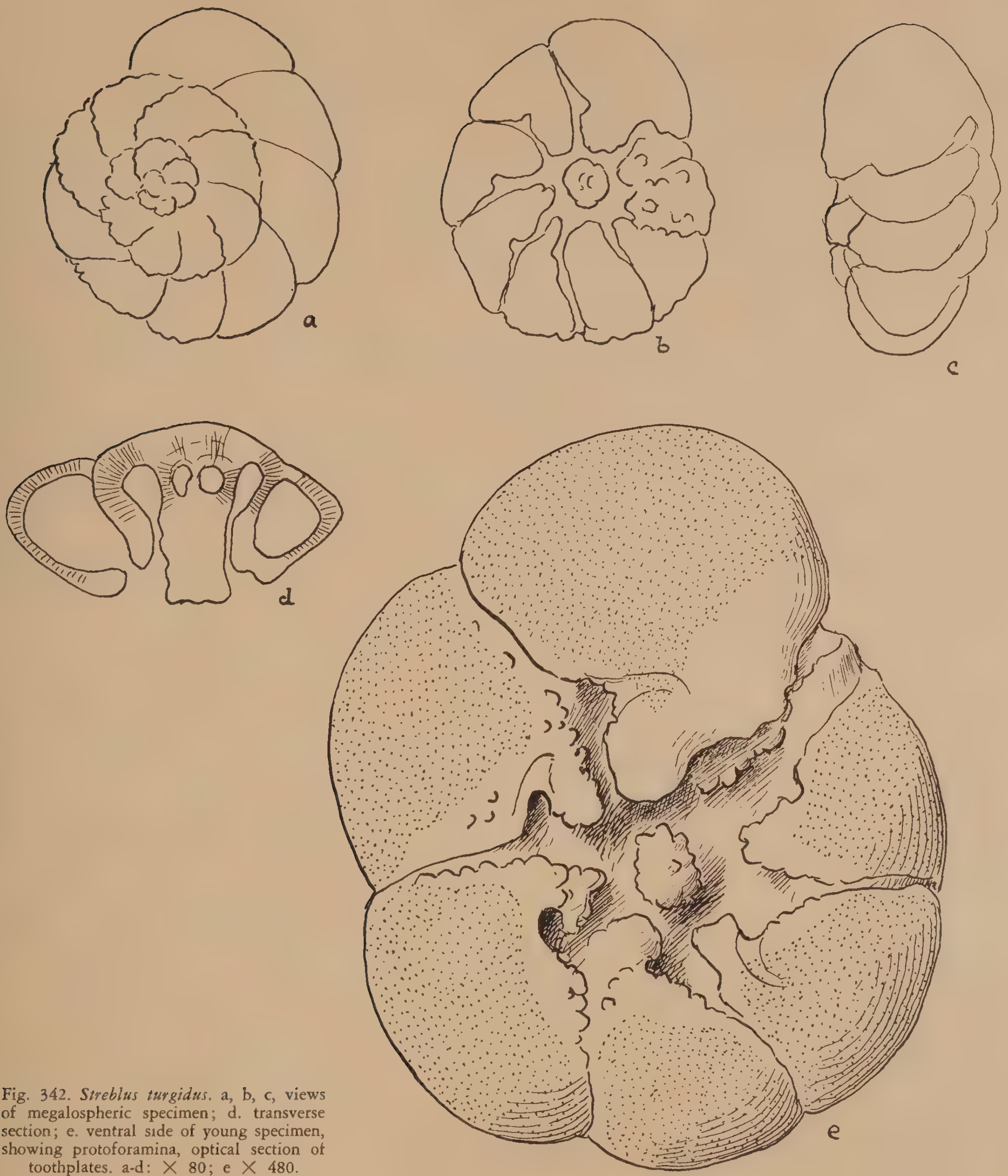

Fig. 342. *Streblus turgidus.* a, b, c, views of megalospheric specimen; d. transverse section; e. ventral side of young specimen, showing protoforamina, optical section of toothplates. a-d: × 80; e × 480.

Conorbis, in which the production of secondary chalk in the umbilical region gives rise to a primitive umbilical canalsystem connecting the chambers of former whorls through the protoforamen with the outer world

Streblus beccarii (Linné)

The type-material of *Streblus beccarii* derives from the Adriatic; I gathered numerous specimens at Rimini, and could compare them with the material from the coast of Holland, gathered at the isle of Voorne near Rockanje. I will describe first all those specimens off Rimini.

The diameter of the tests ranged from 0,62 mm up to 1,62 mm, with several tops, one at 0,8 mm, another at 1,37 mm, and some secondary tops between. The diameter of the proloculi of those 78 specimens studied showed to range from 12,5 μ up to 112,5 μ, with a single top at 62,5 μ, and a second small top at 12,5. The latter are undoubtedly microspheric, the other, from about 38 μ upwards are megalospheric. Here the two megalospheric generations overlap each other obviously, so that a single top is seen.

When numbering the total chambers in a shell, it is easily found, that in the megalospheric shells this number increases with the total diameter of the shell, thus being a function of growth. In the microspheric generation this number is found to be from 28 up to 41 chambers, whereas in the megalospheric generations it ranges from 15 up to 32. But when considering the diameter of the proloculus in the megalospheric forms, one states, that the number of chambers increases with the diameter of the proloculus. Shells with a proloculus of about 62,5 μ diameter have an average of 25 chambers, while shells with a proloculus of about 100 μ diameter have an average of about 27, while those with a proloculus of 112,5 μ show 32 chambers. As this number of chambers is a function of growth, one states, that in megalospheric shells the diameter increases with the diameter of the proloculus, thus in contradiction with most species of Foraminifera.

The outer structure of the shells is now sufficiently known. But the inner structure must have some correction and addition.

The aperture of the last formed chamber, when young, shows the typical structure: a single opening at the base of the apertural face, near the sutural wall. In the microspheric form it is rounded and small, in the megalospheric forms with large proloculus it is somewhat larger. But when the last formed chamber is older, and a new chamber may soon be added, the aperture becomes more complicated by the forming of an overgrowing lip which is connected with the ventral one. This ventral aperture, the protoforamen, thus is situated quite near to the septal foramen, and has a large opening into the wide, flat umbilical cavity. The total test is much flattened, compressed, and its umbilical region is secondarily filled up with knobs of shell material, so that the original ventral foramina open between those knobs. Ventral and dorsal sutures are sunken down, thus giving rise to shallow slits between the chamberwalls. These slits communicate, as is obvious, with the cavities between the umbilical chalk knobs, but they are not, as Brotzen suggests, the ventral foramina. They have nothing to do with them, except that they communicate with the same cavities, into which those ventral foramina open.

Yet those shallow slits between the chambers, running along the sutures, are of some systematic interest, as they are the forebodes of the interseptal canalsystem, found in real *Rotalia,* such as in *Rotalia schroeteriana,* described fully in my Siboga-Report I. Thus the genus *Streblus* must be regarded as the direct ancestor of real *Rotalia,* differing from it only in the lack of a real interseptal canalsystem. Whether this difference must lead to separate those species into different genera is a question of taste.

When a Canadabalsam preparation is made and seen from the ventral side, one dicovers, that firstly the ventral foramina form a short, curved neck, and then open at the umbilical region by means of a widened mouth. The shape of those necks is very peculiar and can be regarded as a typical specific characteristic; a curve in these necks is the place of the toothplate.

We will now turn to the material from the North Sea. Herefrom 61 specimens were analysed.

The diameter of the tests ranged from 0,3 mm up to 0,8 mm, so this diameter here is much smaller. It shows a single top at about 0,4 mm. The curve is otherwise than in the Adriatic material. The diameter of the proloculi ranges from 4 μ up to 54 μ, thus being much smaller in average. Those diameters of proloculi firstly shows a top at about 6 μ, the shells with those proloculi being microspheric. A second group of megalospheric shells shows diameters ranging from 17 μ up to 37 μ, with a top near the smaller diameter, 17 μ. A second group of shells shows diameters ranging from 44 up to 54 μ. This is the smaller group, the most abundant form being that of diameter from 17-37 μ. This form must be regarded as the A_1-generation, those with diameter proloculus from 44-54 μ being obviously the A_2-generation. Those forms with diameter proloculus from 4-8 μ are the B-generation.

Here too the species from the North Sea shows a difference with that from the Adriatic.

In the megalospheric form the number of chambers ranges from 15 up to 20. But in the North Sea material shells with larger proloculus show a smaller number of chambers. Tests with a proloculus of 18,7 μ diameter have an average of 20 chambers, while those with a diameter of the proloculus of 42 μ show an average of number of the chambers of 16. Yet the total diameter of the shell in the megalospheric form increases with the diameter of the proloculus, as in the Adriatic form. But the number of chambers decreases with the increase of the diameter of the proloculus, contrary to the status mentioned in the Adriatic form. In the B-form the number of chambers ranges from 23 up to 39, with an average of 28.

The apertural conditions are not the same as those of the Adriatic form, the septal mouth is somewhat more rounded and not situated so near to the suture whereas the protoforamen is nearly obliterated in ventral view. The total transverse section of the shell shows, that the form from the North Sea is much thicker, less compressed, than the Adriatic one. When a horizontal section is made with my Canadabalsam method, and seen from the dorsal side, the ventral foramina show a total other aspect than those from the Adriatic. For the necks leading to the umbilical openings are broadened so as to build up a secondary chamber, as is known in *Asterigerina* and in *"Rotalia" polystomelloides,* and the openings of those necks into the umbilical region are narrowed again.

All these statements make it clear that the form, found in the North Sea, is a species different from that of the Adriatic. When the Adriatic species must be called *Streblus beccarii,* the *Streblus* from the North Sea, though it suggests much resemblance with the Adriatic species, is quite a different species, as is shown now structurally as well as statistically.

I will call this species *Streblus batavus,* as the difference of this species with the Adriatic *Streblus beccarii* was shown on Dutch material. All records from this region must be regarded as given to this species, as the specimens from Helder, the Zuiderzee, and, I believe, from the English coasts also, show the same characteristics.

A third species occurs in the waters round the Philippines and the East Indian Archipelago. It has been described too as *Rotalia* (*Streblus*) *beccarii* (See Cushman, U.S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 67-68; Philippines, Japan; U.S. Nat. Mus., Bull. 100, 1921, p. 345, Formosa, China-See, Luzon, Mindanao, Jolo, Manila, but not south from the Philippines).

I found the species in abundance in a gathering off Merak, Strait Sunda, depth about 10 fathoms, anchorage. In its total features it resembles closely the *Streblus beccarii* from the Adriatic, but closer examination shows striking differences. These differences are:

1. test dorsally as well as ventrally more convex, and central chalkknob in outgrown specimens more protruding from the umbilical region.
2. chambers somewhat more inflated.
3. in young specimens the central knob higher developed than in those of the Adriatic sea.
4. At ventral side the poreless parts are much larger in the Adriatic than in the East-Indian species.
5. Statistic differences:

a. the diameter of test increases with that of the diameter of proloculus in the sense, as is shows in the North Sea species (*Streblus batavus*), and the line of average is much steeper than that in the Adriatic species (*Streblus beccarii*). The total number of chambers however increases in the same sense, as is found in the Adriatic species. In the North Sea species it decreases when the proloculus increases, from 20 to 15 in the megalospheric forms; in the Adriatic species it increases when the proloculus decreases, from 22 to 32; in the East-Indian species it increases when the proloculus increases, from 16-19 in average.

The megalospheric proloculus in the three species has a diameter:

Adriatic	North Sea	East Indian
40-113 μ	17-54 μ	20-70 μ

The diameter of the whole test in the three species is:

0,75-1,5 mm	0,30-0,85 mm	0,30-0,75 mm

The ratio between diameter and thickness of test in the three species:

3	1,8	1,6

The ratio between diameter and thickness of test in the three species:

12-13	7-8	9

A very striking difference between the two species from the Adriatic and the East Indian, compared with the North Sea species, is, that in the former two the protoforamen and its toothplate are conspicuous, whereas in the North Sea species this protoforamen and its toothplate are nearly obliterated.

These investigations show, that we deal with three different species, each having constant characteristics. So we have to mention them with three different names. As the Adriatic species is considered by Cushman as the most typical one, we may call the Adriatic species *Streblus beccarii* (Linné). The North Sea species I called already *Streblus batavus* nov. spec. The East-Indian and Philippine species I will give here the name of *Streblus turgidus* nov. spec. As these three species differ in several statistic and structural characteristics, they are no varieties of a single species; nor are they subspecies, as in some characteristics they resemble one, and in other characteristics another species.

Genus **Asterorotalia**

This genus differs from *Streblus* in the character of developing porous plates underneath the excavated ventral radial sutures, thus covering the protoforamen as well. But, contrary to *Asterigerina,* in which likewise the protoforamina are closed by porous plates, here forming the supplementary chambers at the ventral side, the plates in *Asterorotalia* always are not broader than the breadth of the suture and open always with an aperture near to the margin.

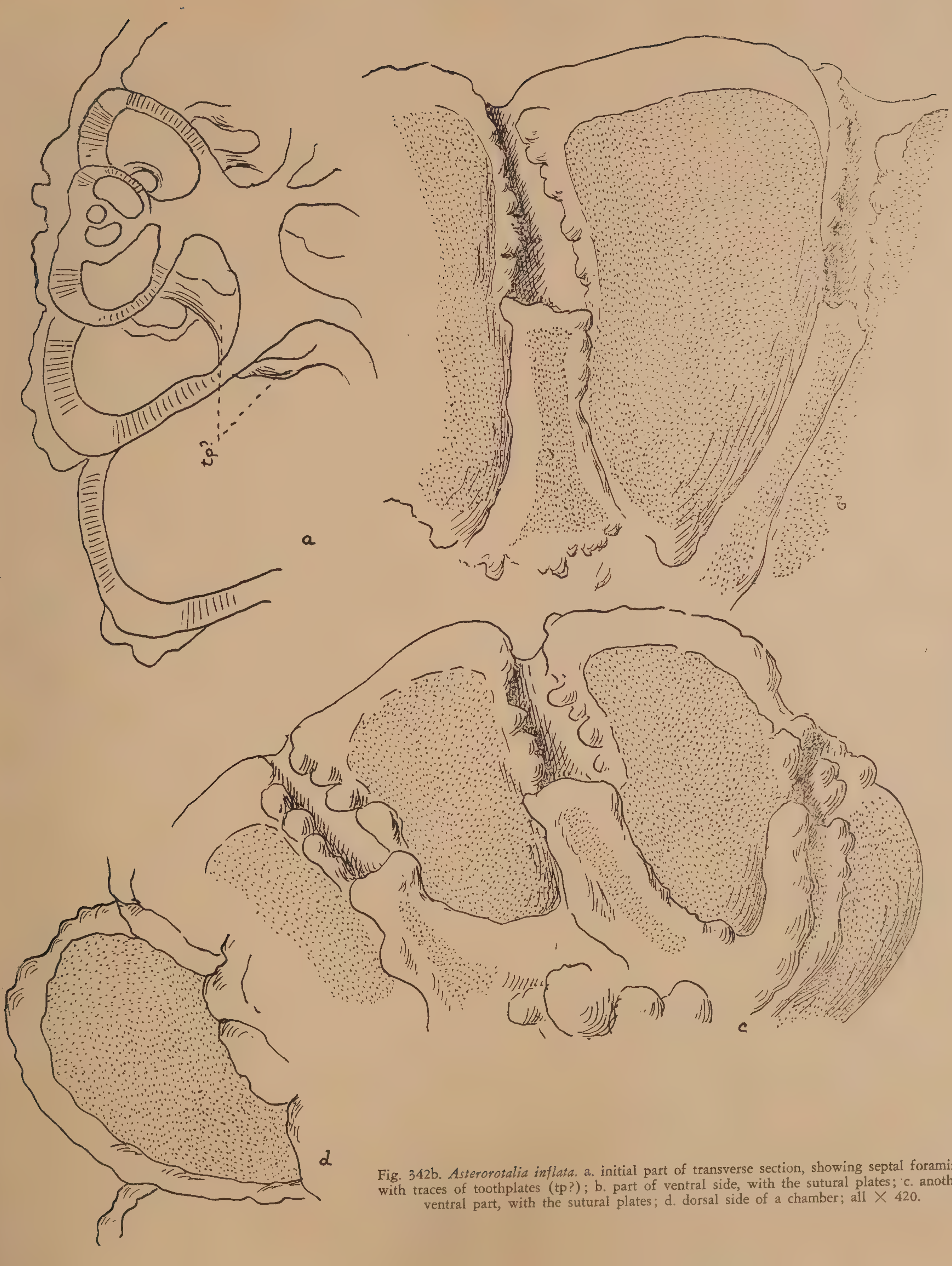

Fig. 342b. *Asterorotalia inflata.* a. initial part of transverse section, showing septal foramina with traces of toothplates (tp?); b. part of ventral side, with the sutural plates; c. another ventral part, with the sutural plates; d. dorsal side of a chamber; all × 420.

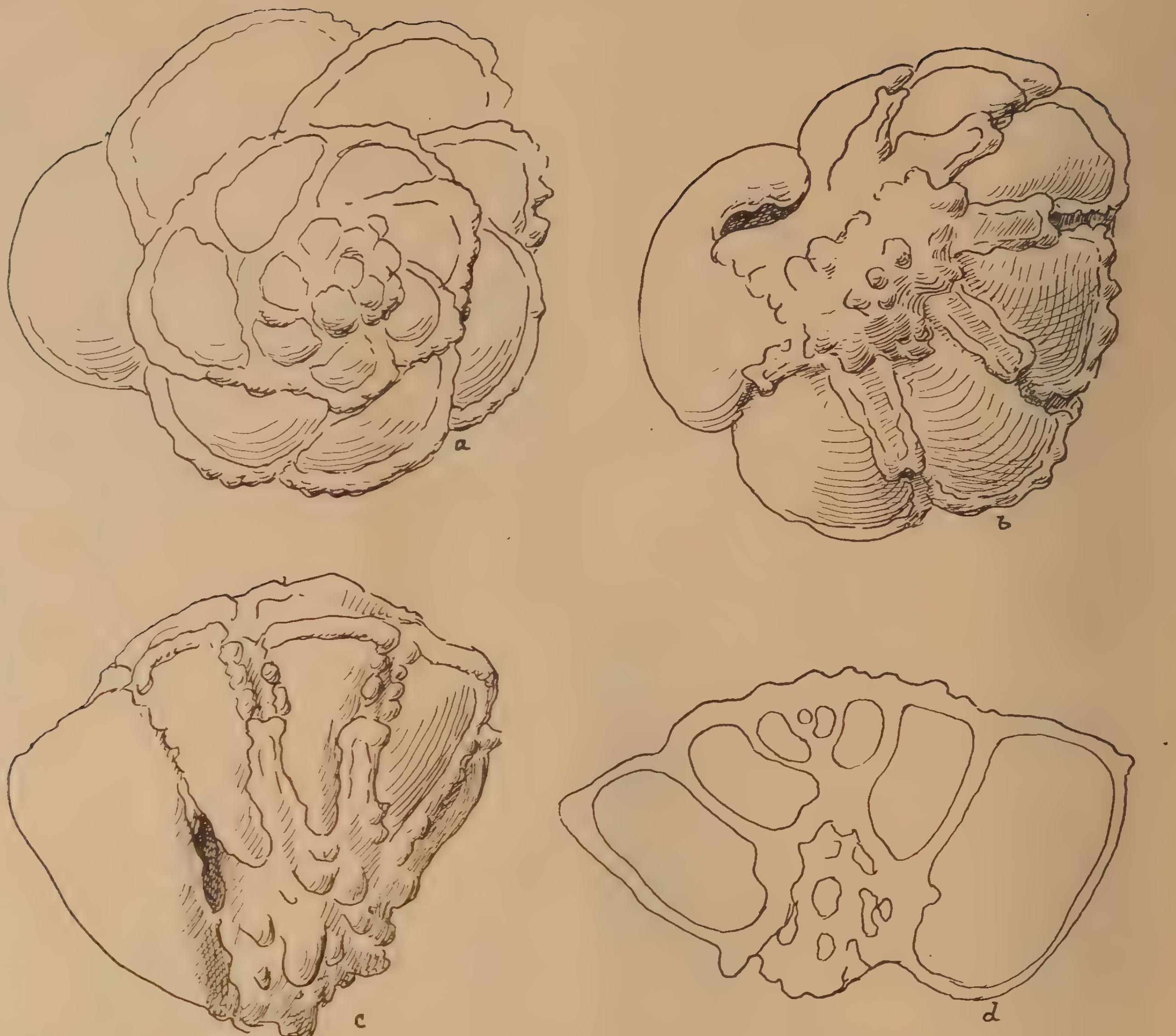

Fig. 342a. *Asterorotalia inflata.* a, b, c, test from dorsal, ventral and apertural sides; d. transverse section; × 110.

I found three different species in recent seas, *A. pulchella,* a second species in the Red Sea, and a third species in the Philippines and the Malay Archipelago, *A. inflata.*

The type of the genus is *Asterorotalia pulchella* (d'Orbigny).

In *Asterorotalia inflata* the aperture shows a close resemblance to *Parrella venusta.* The umbilical knob shows only irregular cavities, and not the typical canalsystem of the *Rotalidae.* Moreover the margin is poreless as in *Parrella venusta,* so that it is very probable, that the genus *Asterorotalia* does not belong in the family of the *Rotalidae,* but is closely related with *Parella.* But the existence of a protoforamen together with that of a deuteroforamen points in the direction of the *Rotalidae,* and so I have maintained its place among the *Rotalidae.*

Asterorotalia inflata (Millet)

This species was found in several gatherings in the Archipelago (off Sacal, near Mindanao, Philippines, off Merak) and was abundant in the Red Sea; it occurred in many specimens at Siboga-station 213, Saleyer. It has been described by Millet as follows:

"This is an interesting variety which occurs in great profusion throughout the region. The conical form of the test and the flat superior face indicate that it is a modification of *Rotalia schroeteriana*; whilst being constant in maintaining the conical shape, the surface is subject to great variation, being smooth in some examples, whilst others are beset with tubercules and spines in various degrees. The peripheral margin is more or less fimbriate and often deeply indented at the sutures. A series of umbilical lobes is always present" (Millet, F. W., Report Recent Forams of the Malay Archipelago, pt. 16, Roy. Micr. Soc., Journ., 1904, p. 504, fig. 5, pl. 10).

The species is directly distinguishable from megalospheric *R. schroeteriana* by the hyaline margin around the dorsal side, and the very conspicuous sutural plates at the ventral side, already observed by Millet.

The dorsal side is slightly convex, with somewhat raised sutures which are very much oblique and ornamented by irregular bosses of hyaline chalk. The ventral side is highly conical, with a central part, filled up with irregular chalk masses. From this centre elongate plates with fine pores are radiating along the sutures, covering half or more of them. Here the protoforamen is more or less covered by the plate. The marginal part of the sutural grooves is free and bordered by irregular bosses of chalk. The aperture is a more or less large opening at the ventral part of the suture and often provided with a thickened lip. Its shape and its place very much resemble that of *Parrella venusta,* and so it may be, that later investigations would prove, that this species belongs in the neighbourhood of *Parrella.* But a toothplate is totally reduced, though the thickened border of the foramen indicates it more or less.

In the umbilical plug the canalsystem, as found in real *Rotalia* or *Streblus,* is replaced by an irregular system of cavities, so that this too points to the possibility, that the species does not belong in the family *Rotalia,* but is a species, allied to *Parrella.* The same can be said of *Asterorotalia pulchella.* As, however, there is no certainty about this question, I have placed it among the *Rotalidae.* I will, however, direct the attention to the fact, that in *Parrella venusta* as well as in *Asterorotalia pulchella* and *A. inflata* the margin is sharp and quite hyaline, without pores. This fact too points to a relation with *Parrella.*

Asterorotalia pulchella d'Orbigny
(Figs. 343, 344)

This species has already been described shortly in the first part of the Siboga Monograph, p. 37. More material, deriving from the anchorage at Merak, Strait Sunda, furnished me with further data about the structure of the test which is not so simple, as in most *Rotalia*-species. In typical *Rotalia,* such as *R. schroeteriana,* the test is only a more advanced *Streblus,* the septa becoming totally double and consequently the septal canals more developed. In *Rotalia pulchella* there are two other typical characters which have been developed, the very conspicuous spines, and the till now not mentioned additional chamberlets on the ventral side.

The spines have been studied by Thalman, who gave a new description of the species. (Eclog. Geol. Helv., 1933, vol. 26, p. 248), in which he changed the name in *Rotalia trispinosa* Thalman. I cannot follow the author in his reasons, why he changed the name, and so I will maintain the name of d'Orbigny's. Thalman says, that the spines in his material, also deriving from the East-Indies, are solid and show no canal at all. I have here to contradict this author, as I found, that all spines in all observed specimens show at least a single central canal and are not at all solid. But the

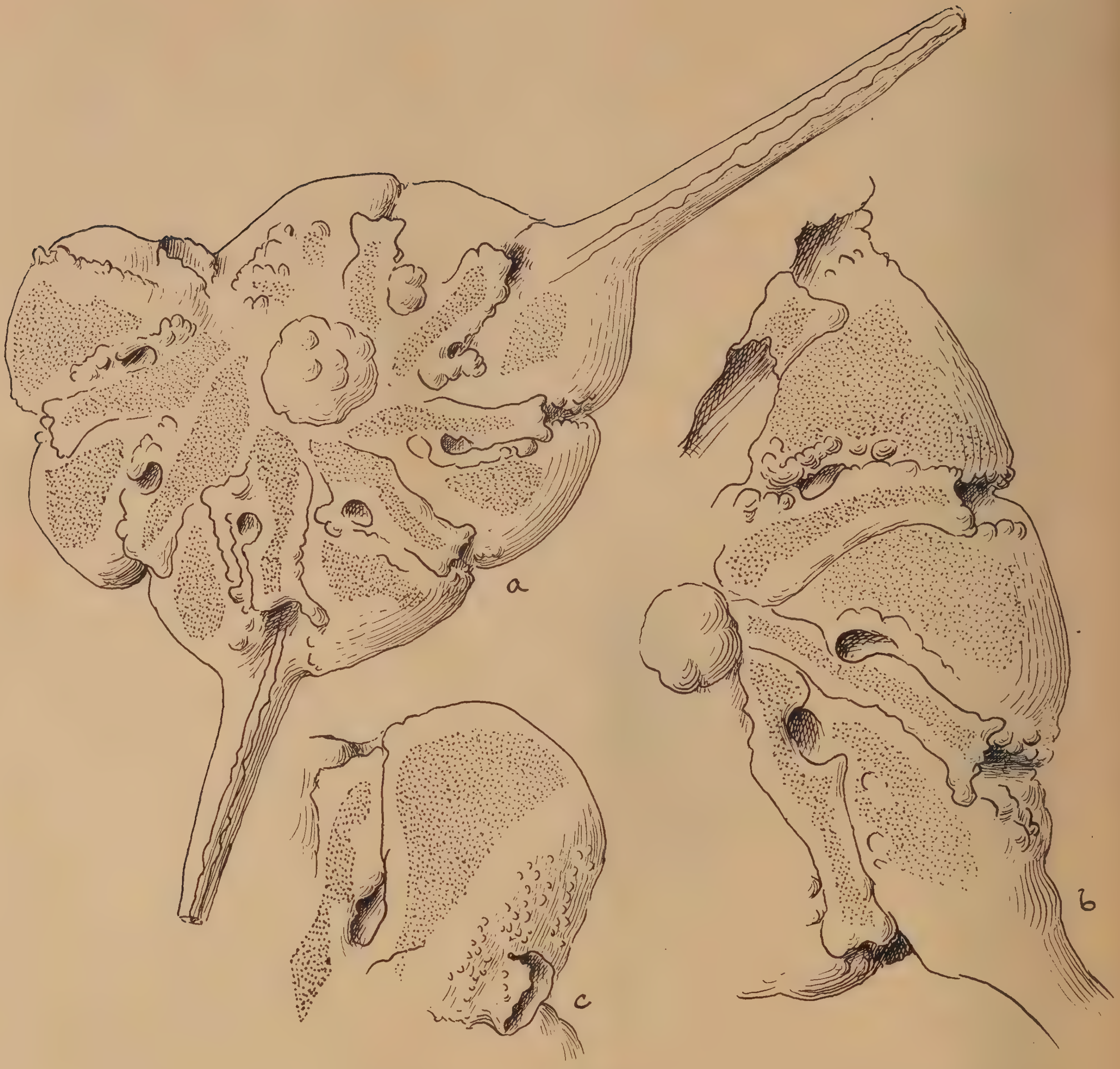

Fig. 343. *Asterorotalia pulchella.* a. ventral side of young specimen, showing protoforamina and the additional chamberlets; b. part of adult specimen, ventral side; c. last formed chamber with the aperture with its lips, the apertural face poreless, but with small tubercules. × 480.

origin of these spines, so highly different from those, found in many allied species of *Rotalia* and *Calcarina,* is very peculiar. In the first whorl three spines are developed and run through the older whorls, often piercing straightly through a chamber. The origin of each spine however is found at the outer wall of three chambers of the first coil which, moreover, consists of few chambers in the megalospheric form, and each spine developed just above (dorsally) a foramen, and its base leaps down to the marginal border of the foramen, suggesting, that it has something to do with that foramen. Its whole structure suggests strongly a toothplate; the folded part of it is open at its base, but very soon it closes and forms the inner canal of the spine. So this canal has no real connection with the umbilical system, as I suggested in my paper, cited above, but with the hollow of the chamber, in which the foramen, at the border of which the toothplate is attached, forms the septal opening.

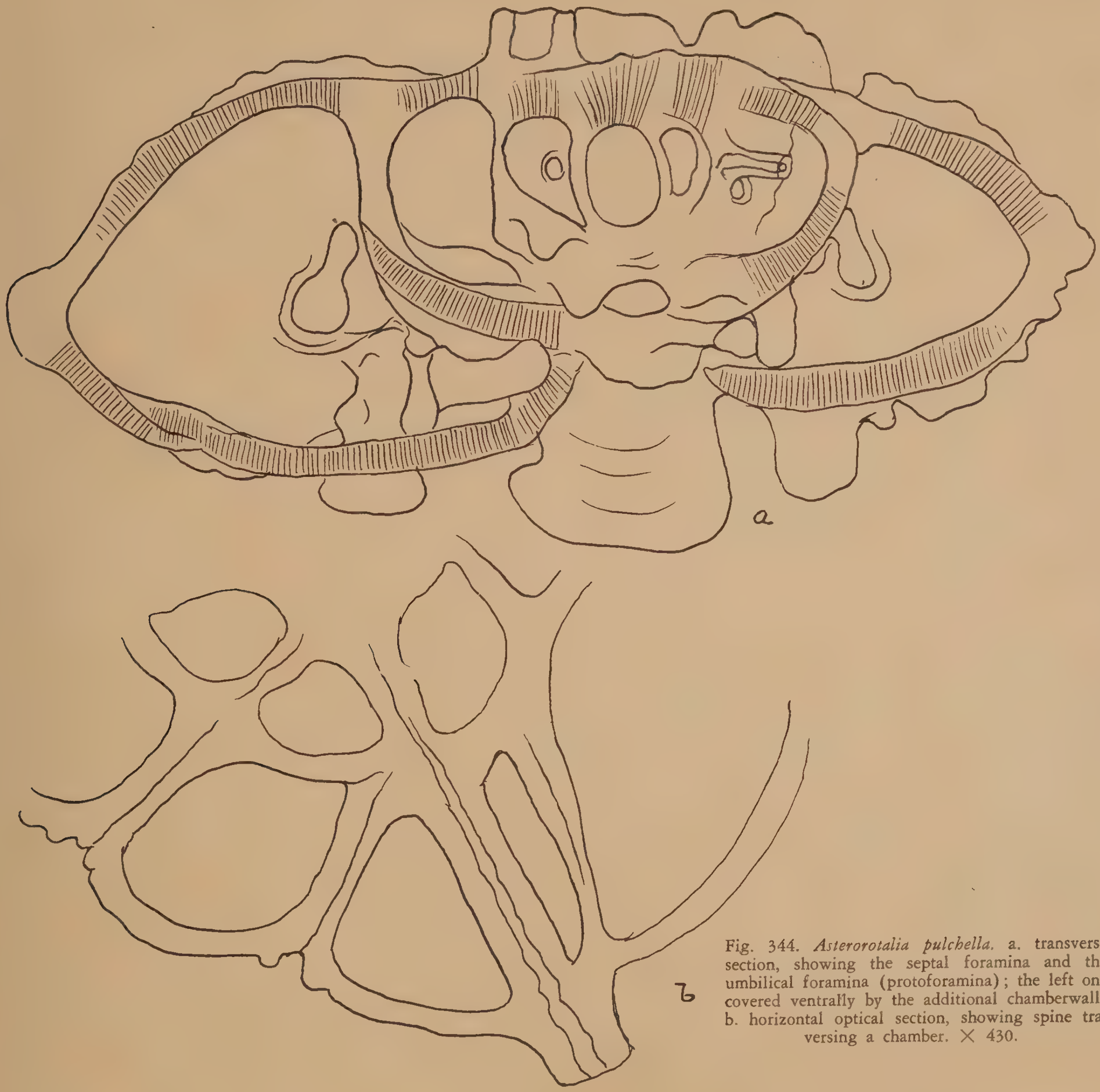

Fig. 344. *Asterorotalia pulchella.* a. transverse section, showing the septal foramina and the umbilical foramina (protoforamina); the left one covered ventrally by the additional chamberwall; b. horizontal optical section, showing spine traversing a chamber. × 430.

The umbilical system is formed by the protoforamina which are present as in the genus *Streblus,* forming the ventral foramina of the chambers. They easily can be seen in a clarifier from the ventral side, each of the lastformed whorl opening into the outer world. But the very much depressed sutures, at whose umbilical ends the protoforamina are opening, are covered by a special plate, a long plate, with raised borders, and running from the umbilical knob toward a place underneath the margin, where it ends bluntly, slightly enlarged. This plate is pierced by protopores, and consequently is very much resembling the plates, found covering the protoforaminal hollow of *Reinholdella.* But, while in *Reinholdella* the foramen itself is closed by the plate, here the foramen remains open, as in older whorls it has to form the umbilical canalsystem, and the sutural hollow is closed by the plates only. As, intelligibly, the openings of the former whorls at the ventral side open into the umbilical cavity, and as this cavity is closed by the additional "ventral chambers", these former openings open now into the lumen of these "chambers", and consequently they open with the openings of these chambers, found at the blunt end of the plates underneath the margin. The whole system thus is very much resembling that, which I have described from *Rotalia polystomelloides* (Siboga I, 1927, pl. 16, figs. 3 and 6). The aperture and the septal foramina of our species differ in some respects from those, found in *Streblus,* as the aperture is more areal than interiomarginal. It shows some resemblance to that of the genus *Parrella.*

So, when considering all these points, we come to the conclusion, that *Astrorotalia pulchella* is characterized by the following features:

Irregular chalkbosses and ridges at sutures, especially at dorsal side; at ventral side protoforamina opening next into very elongated "additional chambers"; three spines developed, formed by the toothplates of firstformed chambers, hollow and opening at their base into the lumen of a chamber. Ventral canalsystem covered by the walls of "additional chambers", and opening underneath the margin in the sutural hollow.

It will be clear that these characters, so different from real *Rotalia,* such as *Rotalia papillosa* and *R. schroeteriana,* are important enough to erect a new genus.

Genus **Hyalinea**

This genus seems to be very closely allied to *Streblus.* The difference is, that in *Streblus* the protoforamen is opening into the radiating sutures, whereas in *Hyalinea* they open into the spiral sutures. Moreover the umbilical cavity is very shallow and large, so that the test becomes nearly planospiral. The aperture is riding on the margin consequently, and the pores are, as in *Streblus* and *Rotalia,* fine protopores. But, otherwise than in *Streblus,* the surface of the test is smooth and does not show the knobs of secundary chalk, characteristic for many species of *Streblus.* In the microspheric form a somewhat reduced and in any way primitive canal system is found in the centre of the umbilical chalk mass. This fact may suggest, that *Hyalinea* is rather an altered *Rotalia* than that it is an advanced form of *Streblus.*

The only species, hitherto known belonging to the new genus is *Hyalinea baltica,* hitherto known as *Anomalina baltica.* The protoforamina, together with the protopores, clearly show that this species has nothing to do with *Anomalina.*

The type of the genus is *Hyalinea baltica* (Schroeter).

Hyalinea baltica (Schroeter)
(Figs. 345-348)

I have already made a rather exhaustive study of this species in my treatise of the Ammontatura Foraminifera (Publ. Staz. Zool. Napoli, Vol. 12, 1932, p. 136-140). Here I stated, that the

A_1 and A_2-form showed statistically two groups which are very closely related, while the B-form stood much more aside. I mentioned also, that I found ventral foramina, thus indicating, that this species with its fine pores, could not belong to the genus *Anomalina* which always shows rather coarse pores and does not possess ventral foramina.

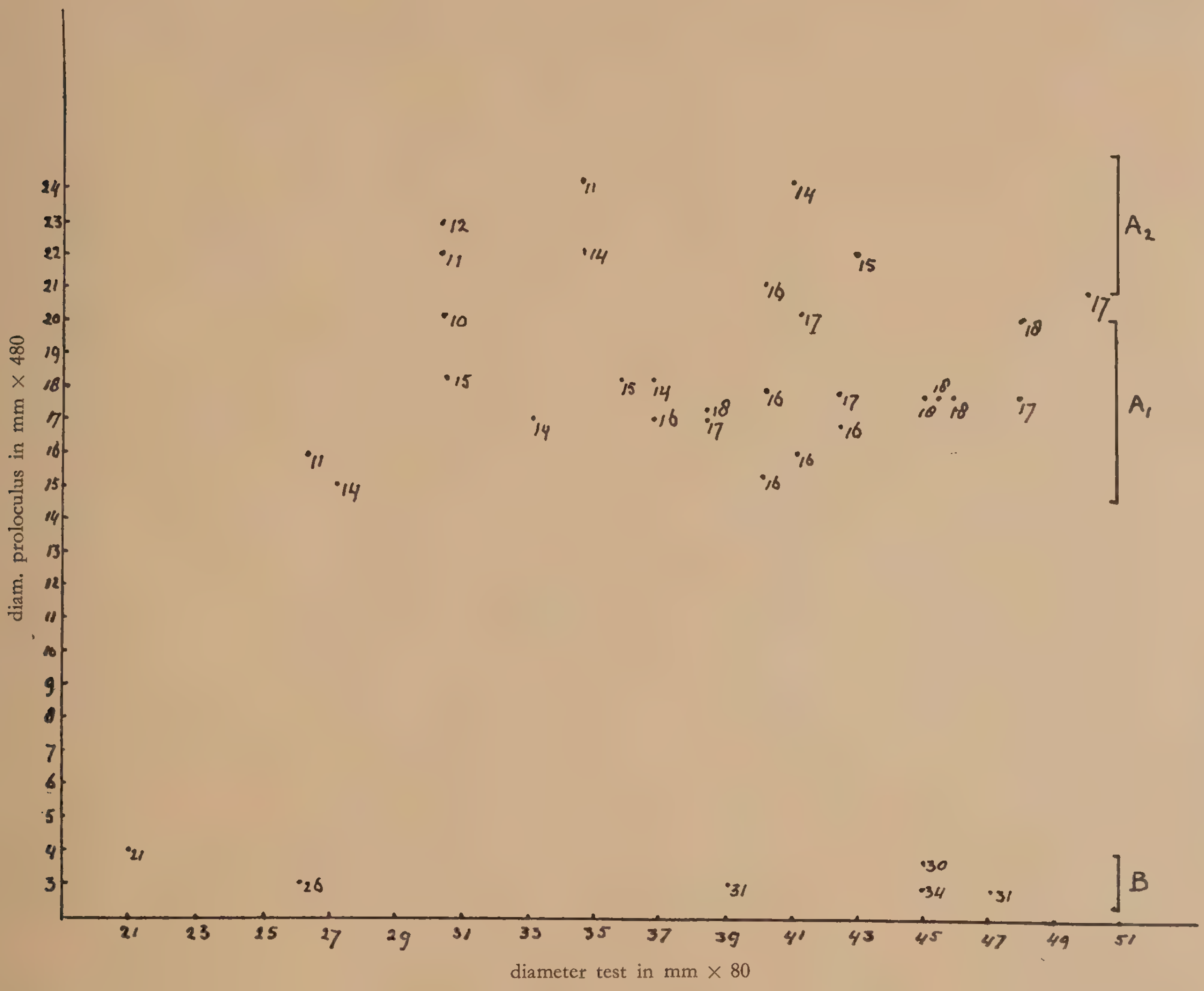

Fig. 345. *Hyalinea baltica.* Diagram showing relation between diameter of test and diameter of proloculus. The A_1- and A_2-generations are only distinguishable by the number of chambers. May be, that the species is paratrimorphic.

I restudied the species again, as I found it in some larger quantities at 2° 17′ S., 99° 27′ E., depth 377 fathoms. It occurred in several other gatherings south of Sumatra, and at 8° 15′ S., 118° 56′ E., 340 fathoms.

It is very probable, that in some cases the species *Anomalina ariminensis* has been confused with *A. baltica.* But the fine pores of the latter are very typical. Cushman does not mention the species for the Pacific Ocean. There is some possibility too, that it has been described as some small *Operculina* (Bannink, P. D., Een monografie van het genus *Operculina* d'Orbigny; thesis Leiden, 1948, *Operculina ammonoides,* p. 81-82). But the lack of any trace of a marginal chord shows the real systematic place.

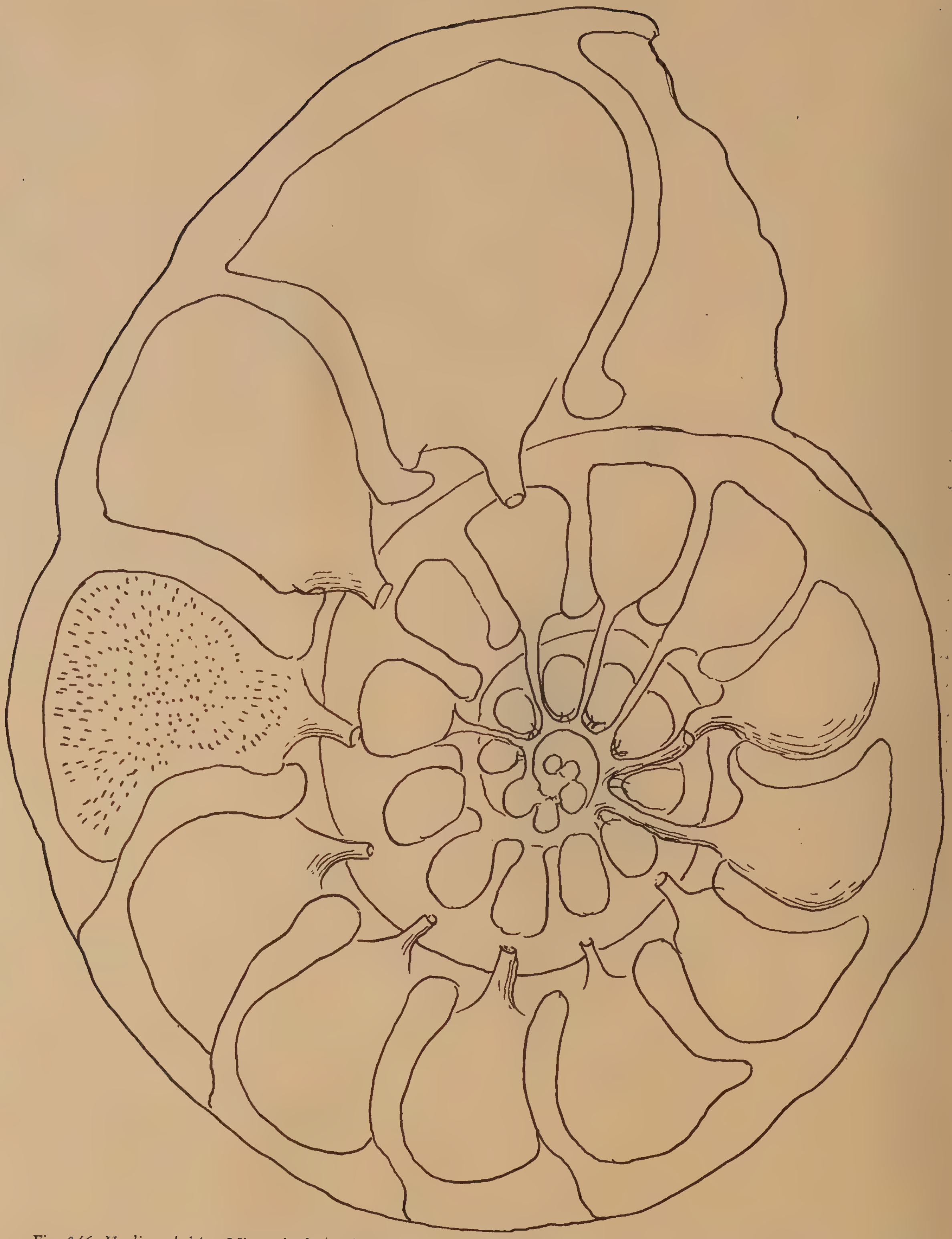

Fig. 346. *Hyalinea baltica.* Microspheric specimen, ventral side, optical section. The ventral foramina (protoforamina) form in the centre of the test a simple umbilical canalsystem, as is found in *Rotalia.* This shows the status of *Hyalinea* between *Streblus* (without real ventral canalsystem) and *Rotalia* with complicated system. × 480.

In some very clear and translucent specimens, both microspheric and megalospheric, I detected the ventral foramina, opening in the later chambers with a short canal at the ventral umbilical region, just underneath the chalk-ridge which borders ventrally the last row of chambers, whereas the ventral foramina of the former coils of chambers open into a real spiral canal, formed by the closing of this chalk ridge, with secondary material. This could even be seen without sectioning the shells. Thus I have to amplify my study from 1932 in that way, that in the megalospheric forms too the canalsystem can be found. In very large shells I found even interseptal canals. Here I must point out, that in older shells parasitic organisms often have drilled canals into the clear shell substance, which may be taken (as Douvillé did in another case) for real canalsystems. But these are always very irregularly situated.

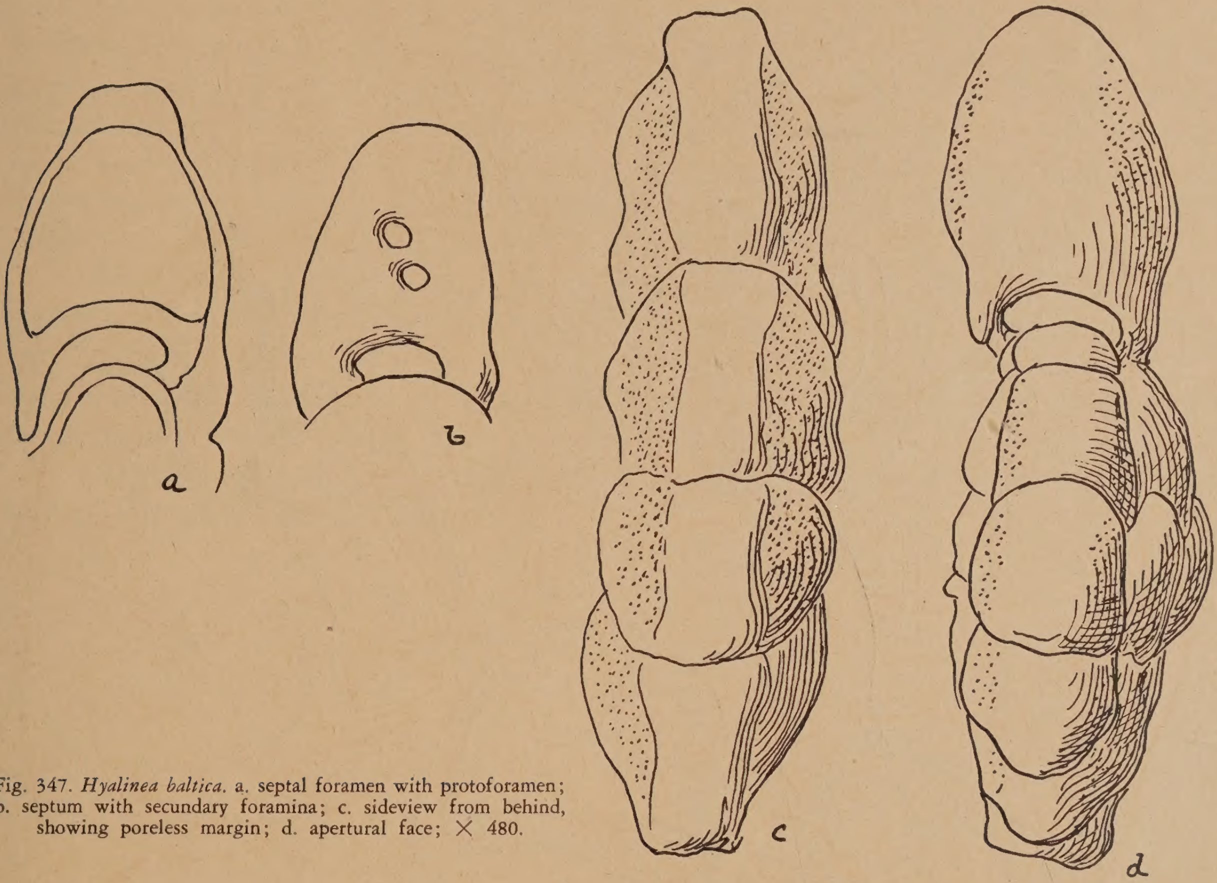

Fig. 347. *Hyalinea baltica*. a. septal foramen with protoforamen; b. septum with secundary foramina; c. sideview from behind, showing poreless margin; d. apertural face; × 480.

The proloculus of the B-form always measures 6-8 μ in diameter. It is followed by 21-31 chambers, in three coils. Each chamber shows a very peculiar mouth, nearly symmetrically found above the basal suture of the chamber, marginal, and overlapped by a distinct lip. When observed very accurately, the aperture always bends to the ventral side of the shell, thus making it clear, that the shell is really trochoid. Only at this ventral side, found best in transverse section in microspheric shells, the ventral foramina open, thus indicating, that the species has nothing to do with real planospiral species as *Nonion*. Outgrown specimens of the B-form have a diameter of about 0,50 mm.

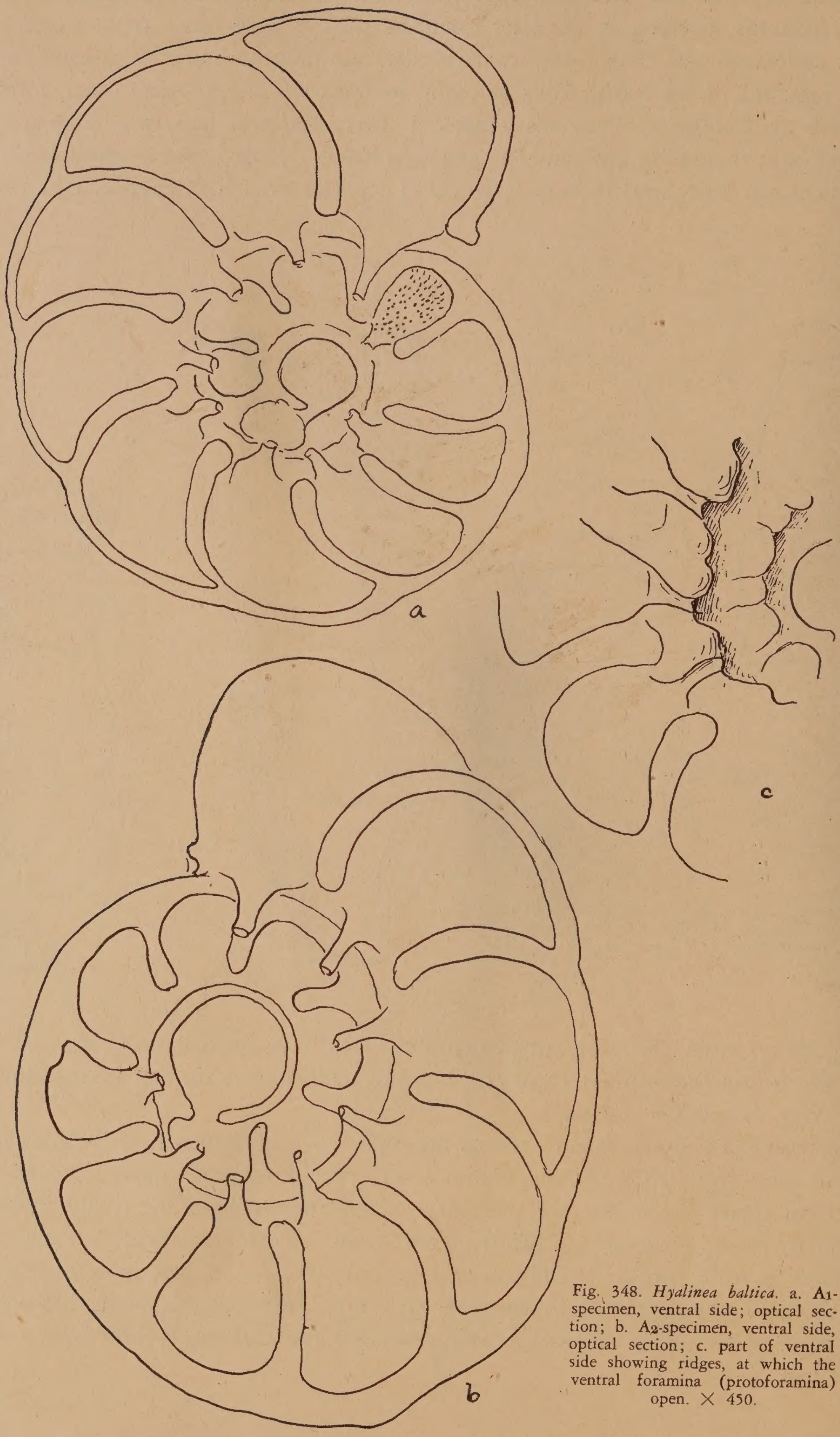

Fig. 348. *Hyalinea baltica.* a. A_1-specimen, ventral side; optical section; b. A_2-specimen, ventral side, optical section; c. part of ventral side showing ridges, at which the ventral foramina (protoforamina) open. × 450.

The A_1-form, with a proloculus from 31 to 37 μ diameter, shows a length from 0,30 to 0,56 mm, with 18 chambers in the adult.

The A_2-generation, with a proloculus from 41-48 μ diameter, shows mostly 16 chambers in the adult, but a very large specimen had 18 of them; it had a diameter of the shell of 0,60 mm.

Thus the species shows the three generations, and I am thus authorized to give it a name. It cannot be called *Anomalina,* since the very fine pores, the typical apertural lip, the ventral foramina and the somewhat reduced canalsystem do not agree with the characteristics of that genus. Ventral foramina with fine pores occur in the genera *Streblus, Rotalia,* while the *Camerinidae* do not come into consideration, as they always are characterized by the marginal chord, which cannot be found in our species. Apertural lips occur in several species of the genus *Streblus,* but in real *Eponides* the umbilicus is a closed one, while in our species it is only open with respect to the last formed coil of chambers, as here the ventral foramina open with a short canal into the umbilical space. Thus the species here studied stands between typical *Streblus* and typical *Rotalia.* This may be in this way an ancestral form of *Rotalia,* but it may be also, that it shows the features of a somewhat degenerated *Rotalia.* The very flat trochus of the species indicates the latter suggestion.

Only the genus *Streblus,* with its typical representative species, *Streblus beccarii,* shows the indication of a canalsystem, which has not been developed into a real one. Here too the trochus is very flat. The pores in *S. beccarii* are very fine also, the shell material clear, as in our species. Only the amount of secondary chalk in *S. beccarii* is larger than in our species, but the aperture here too shows the indication of a lip.

Thus we have to call our species *Streblus baltica* (Schroeder), or to give it a new generic name; I have chosen that of *Hyalinea.*